Electronic Supplementary Material (ESI) for Green Chemistry.

Supporting Information

Catalyst-free Decarboxylative Deuteration Using Tailored Photoredox-Active Carboxylic Acids

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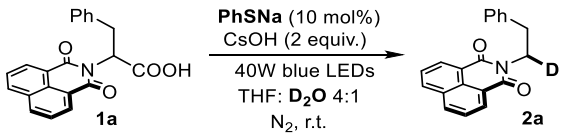
1. General Information.

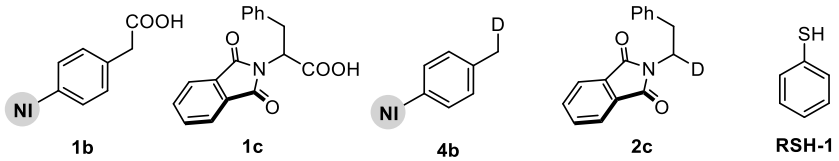
All the reactions were conducted in oven-dried Schlenk tubes under nitrogen atmosphere. All solvents and chemicals were obtained from commercial suppliers and used without further purification. Products were purified by flash column chromatography using silica gel (200-300 mesh). ^{1}H and ^{13}C NMR spectra were obtained by 600 MHz Bruker Ascend 600 spectrometer. Tetramethylsilane (TMS) was used as the internal standard for the measurement of chemical shifts (δ) in ppm. Chemical shifts are reported in ppm (δ). NMR experiments were run in $CDCl_3$ as indicated, ^{1}H NMR spectra are referenced to the resonance from residual $CHCl_3$ at 7.26 ppm. ^{13}C NMR spectra are referenced to the central peak in the signal from $CDCl_3$ at 77.0 ppm. The multiplicities of ^{1}H NMR resonances are expressed by abbreviations: br (broad singlet), s (singlet), d (doublet), t (triplet), quartet (q), m (multiplet) and combinations thereof for highly coupled systems. ^{13}C NMR spectra were run as proton decoupled experiments. ^{1}H and ^{13}C signals where appropriate are described by chemical shift δ (multiplicity, *J* (Hz), integration). Blue light source for photoreaction was Kessil 68 A160We. HRMS (ESI) spectra were obtained using a Waters Q-Tof premierTM mass spectrometer. UV-vis measurements were carried out on a Shimadzu UV-2401PC spectrophotometer equipped with photomultiplier detector, double beam optics and D2 and W light sources.

2. Optimization of the reaction conditions

Table S1. Direct decarboxylative deuteration of PAC-1a

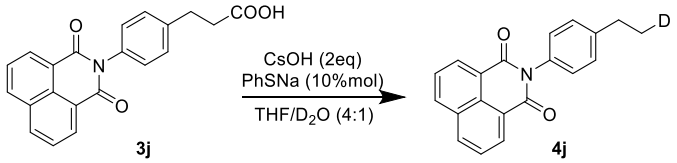


Entry	Variation of standard conditions	Yield[b]	D-inc[c]
1	RSH-1 instead of PhSNa	56	93
2	RSH-1 & **1b** instead of PhSNa & **1a**	64[d]	90[d]
3	RSH-1 & **1c** instead of PhSNa & **1a**	N.D.[e]	-
4	none	70	95
5	Acetone instead of THF	59	93
6	ACN instead of THF	47	94
7	DMF instead of THF	8	-
8	Cs_2CO_3 instead of CsOH	55	99
9	2,6-Lutidine instead of CsOH	28	99
10	2,4,6-Collidine instead of CsOH	28	99
11	CsOH (1.5 eq)	60	99
12	CsOH (1.0 eq)	45	99



Reaction conditions: **1a** (0.1 mmol), sodium phenylthiolate (PhSNa) (10 mol%), THF/D_2O (4:1, v/v; 2 mL), base (2 eq), blue LEDs, 3 d. [b] Measured by NMR using 1,3,5-trimethoxybezene as internal standard. [c] Deuterium incorporation was determined by ^1H NMR analysis. d) The yield or deuterium incorporation of product **4b**. e) The yield or deuterium incorporation of product **2c**. THF = Tetrahydrofuran, DCM = Dichloromethane, DMF = Dimethylformamide, ACN = Acetonitrile, N.D. = not detected.

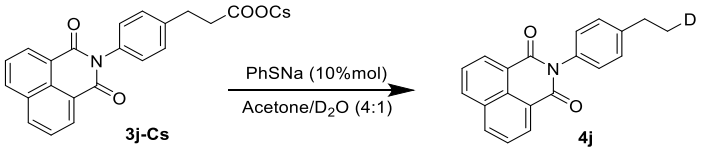
Table S2. Direct decarboxylative deuteration of PAC-3j.



Entry	Variation of standard conditions	Yield[b]	D-inc[c]
1	none	N.D.	-
2	Acetone instead of THF	N.D.	-
3	DCM instead of THF	N.D.	-
4	ACN instead of THF	N.D.	-
5	DMF instead of THF	N.D.	-

Reaction conditions: **3j** (0.1 mmol), sodium phenylthiolate (PhSNa) (10 mol%), THF/D_2O (4:1, v/v; 2 mL), base (2 eq), blue LEDs, 3 d. [b] Measured by NMR using 1,3,5-trimethoxybezene as internal standard. [c] Deuterium incorporation was determined by ^1H NMR analysis. THF = Tetrahydrofuran, DCM = Dichloromethane, DMF = Dimethylformamide, ACN = Acetonitrile, N.D. = not detected.

Table S3. Decarboxylative deuteration of cesium 3-(4-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) phenyl) propanoate (3j-Cs)

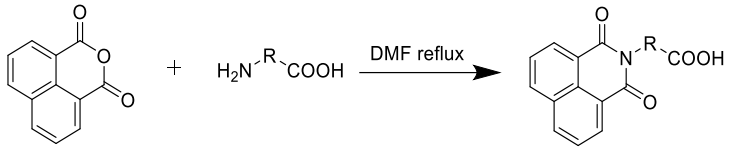


Entry	Variation of standard conditions	Yield[b]	D-inc[c]
1	none	68	95%
2	THF instead of Acetone	65	94
3	ACN instead of Acetone	30	97
4	DMF instead of Acetone	20	99
5	Toluene instead of Acetone	10	-
6	DCM instead of Acetone	N.D.	-
7	Acetone/D_2O (2:1)	52	95%
8	Acetone /D_2O (9:1)	62	82%
9	Acetone /D_2O (19:1)	60	66%
10	D_2O 100eq	49	50%

Reaction conditions: **3j-Cs** (0.05 mmol), **PhSNa** (10 mol%), Acetone/D_2O (4:1, v/v; 2 mL), blue LEDs, 4 d. [b] Measured by NMR using 1,3,5-trimethoxybezene as internal standard. [c] Deuterium incorporation was determined by ^1H NMR analysis. THF = Tetrahydrofuran, DMF = Dimethylformamide, ACN = Acetonitrile, DCM = Dichloromethane, N.D. = not detected.

3. All General Experimental Procedures.

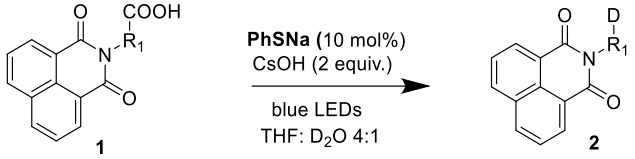
3.1 General procedure for synthesis of PACs.



A mixture of amino acid (10 mmol) and 1,8-naphthalic anhydride (10 mmol) in DMF (25 mL) was heated to reflux overnight under N_2. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product. (dichloromethane/MeOH: 10/1), to afford 1,8-naphthalimide derivatives[1].

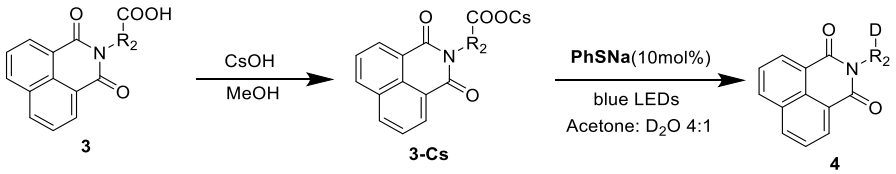
3.2 General procedure for decarboxylative deuteration

a) General procedure for decarboxylative deuteration of PAC (GP1).



An oven-dried Schlenk tube (10 mL) was equipped with a magnetic stir bar, **PAC-1** (1 equiv., 0.1 mmol), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 1.6 mL THF, 0.4 mL D_2O and cesium hydroxide solution (2 equiv., 0.2 mmol) were added successively with syringe under N_2. The tube was then sealed and was stirred under the irradiation with blue LEDs at room temperature for 3 d. After the reaction was finished, the reaction mixture was extracted by ethyl acetate, dried by anhydrous Na_2SO_4, filtered and collected the organic layer. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product.

b) General procedure for decarboxylative deuteration of PAC-Cs (GP2).

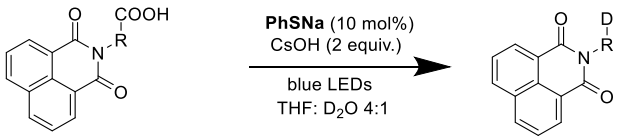


A 100 mL round-bottom flask equipped with a stirring bar was charged with **PAC 3-Cs** (10 mmol, 1.0 equiv.), cesium hydroxide solution (9 mmol, 0.9 equiv.), MeOH (40 mL). The mixture was stirred for 1 hour at room temperature. The solvent and water (by-product) were removed under reduced pressure. The obtained solid was washed with ethyl acetate, filtered and dried in a vacuum drying box (50°C, 5h) to get the anhydrous white solid.

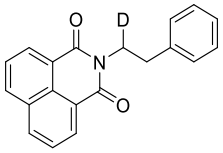
An oven-dried Schlenk tube (10 mL) was equipped with a magnetic stir bar, cesium carboxylate (1 equiv., 0.05 mmol), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 1.6 mL acetone, 0.4 mL D_2O, were added successively with syringe under N_2. The tube was then sealed and was stirred under the irradiation with blue LEDs at room temperature for 4-5 d.

After the reaction was finished, the reaction mixture was extracted by ethyl acetate, dried by anhydrous Na_2SO_4, filtered and collected the organic layer. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product.

3.3 General procedure for scale up decarboxylative deuteration (GP3).

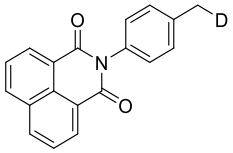


An oven-dried round-bottom flask (25 mL) was equipped with a magnetic stir bar, PAC (1 equiv., 5 mmol), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 32 mL THF, 8 mL D_2O and CsOH (2 equiv., 10 mmol) were added successively with syringe under N_2. Then stirred under the irradiation with blue LEDs at room temperature. After the reaction was finished, the reaction mixture was extracted by ethyl acetate, dried by anhydrous Na_2SO_4, filtered and collected the organic layer. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product.



2-(2-phenylethyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2a)

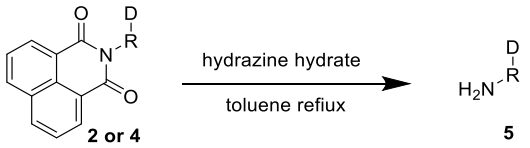
Following GP3 with reaction time of 5 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2a** was obtained in 65% yield as a withe powder with 96% D-incorporation (determined by ^{1}H NMR).



2-(4-(methyl-*d*) phenyl)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4b)

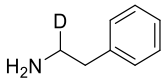
Following GP3 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/DCM =1:2), compound **4b** was obtained in 91% yield as a withe powder with 98% D-incorporation (determined by ^{1}H NMR).

3.4 General procedure for removal of NDC (GP4).



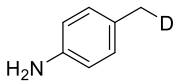
A mixture of products **2** or **4** (1 equiv., 0.3 mmol) and hydrazine hydrate (10 equiv., 3 mmol) in toluene (2 mL) was heated to reflux overnight under N_2. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain

the desired product.



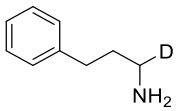
2-phenylethan-1-*d*-1-amine (5a)

After purified by column chromatography on silica gel (eluent: petroleum ether/Acetone =1:4), compound **5a** was obtained in 62% yield as a yellow oil with 96% D-incorporation (determined by ^{1}H NMR).



4-(methyl-*d*) aniline (5b)

After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =1:1), compound **5b** was obtained in 86% yield as a yellow oil with 98% D-incorporation (determined by ^{1}H NMR).

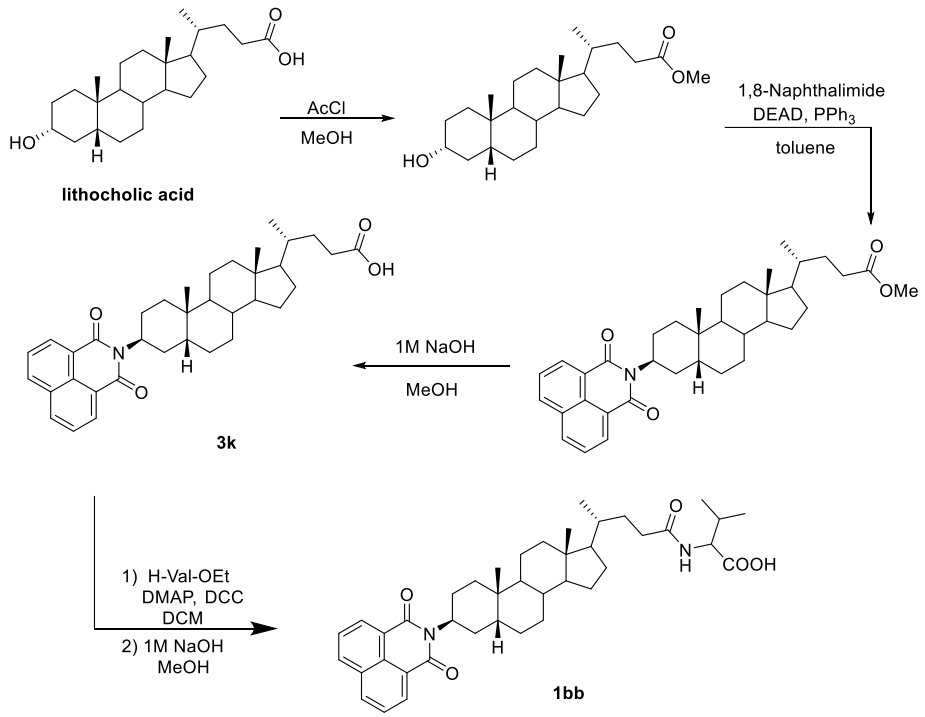


3-phenylpropan-1-d-1-amine (5m)

After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =1:1), compound **5m** was obtained in 67% yield as a yellow oil with 95% D-incorporation (determined by ^{1}H NMR).

3.5 Compounds preparation.

Preparation of **PAC-3k and 1bb**[2]:

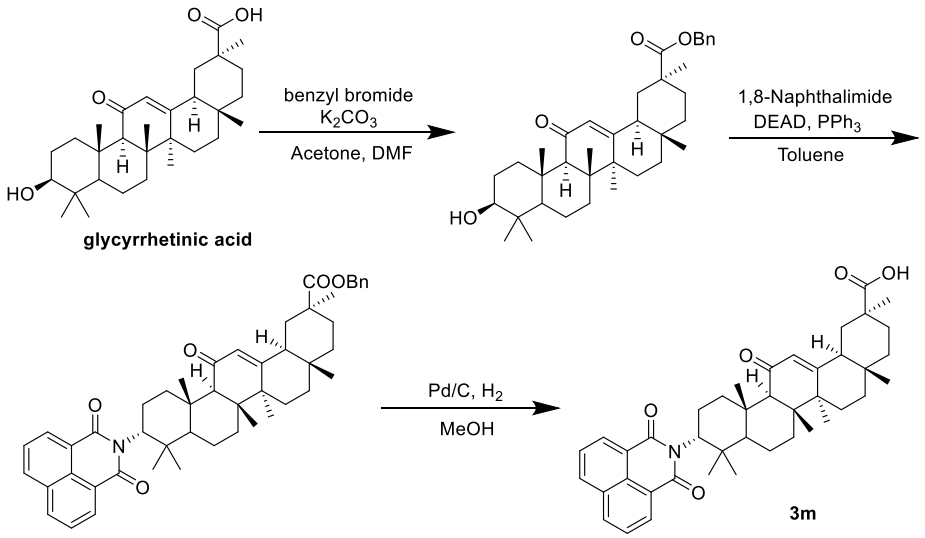


Acetyl chloride (50 µl) was added to a solution of lithocholic acid (500 mg, 1.32 mmol) in methanol (5 ml). The mixture was stirred for 4 h at room temperature, then poured into water. The solution was filtered, and the filtrate was evaporated. The residue was recrystallized from hexane to afford methyl lithocholic acid. Then added it (1 mmol, 1.0 eq), triphenylphosphine (2 mmol, 2.0 eq), 1,8-naphthalimide (2 mmol, 2.0 eq), and DEAD (2 mmol, 2.0 eq) in toluene (5 ml). After 2.5 h, the reaction mixture was poured into water, and extracted with ethyl acetate. The organic layer was washed with water, dried by anhydrous Na_2SO_4, and evaporated. The residue was chromatographed on silica gel (hexane/ EtOAc 4:1) to afford product. Then it was dissolved in 20 mL MeOH. A solution of NaOH (1 M, 8ml) was added under vigorous stirring. After full conversion was indicated by TLC, MeOH was then removed at under high vacuum. EtOAc (10 ml) was added, and the pH adjusted to 4 with HCl (1M). The mixture was poured into a separation funnel, the layers separated, and aqueous layer was extracted with EtOAc (5 ml x3). The combined organic extracts were washed with brine (5 mL), dried by Na_2SO_4, and concentrated under reduced pressure to afford **3k**.

Then The 3k (0.2 mmol, 1.0 eq.), H-Val-OEt·HCl (0.22 mmol, 1.1eq.), and DMAP (0.02 mmol, 0.1 equiv.) were added. Then a solution of N, N´- dicyclohexylcarbodiimide (DCC) (0.22 mmol, 1.1 eq.) in DCM (3 mL) was added slowly at room temperature. The vial was sealed and the reaction stirred for 24h. DCM was then removed at under high vacuum. The residue was chromatographed on silica gel (hexane/ EtOAc 3:1). Then it was dissolved in 5 mL MeOH. A solution of NaOH (1 M, 2ml) was added under vigorous stirring. After full conversion was indicated by TLC, MeOH was then removed at under high vacuum. EtOAc (5 ml) was added, and the pH adjusted to 4 with HCl (1M). The mixture was poured into a separation funnel, the layers separated, and aqueous layer was extracted with EtOAc (5 ml x3). The combined organic extracts were washed with brine (5 mL), dried by Na_2SO_4, and concentrated under reduced pressure to afford **1bb**.

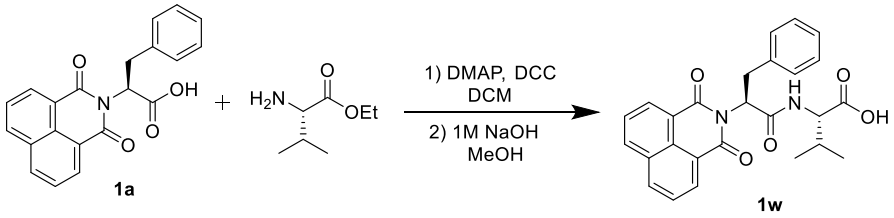
The substrates **3l** and **1cc** were also synthesized by this procedure.

Preparation of **PAC-3m**:



Potassium carbonate (2.2 mmol, 1.1 eq.) was added to a solution of glycyrrhetinic acid (2.0 mmol, 1 eq.) in acetone (10 ml) and DMF (1 ml). After 30 min, benzyl bromide (3.0 mmol, 1.5 eq.) was added, and resulting solution was stirred at room temperature for 3 h. EtOAc and water were added to the reaction mixture. The organic layer was washed with water, dried by Na_2SO_4, and evaporated. The residue was chromatographed on silica gel (DCM/ MeOH 10:1). Then added it (1 mmol, 1.0 eq), triphenylphosphine (2 mmol, 2.0 eq), 1,8-naphthalimide (2 mmol, 2.0 eq), and DEAD (2 mmol, 2.0 eq) in toluene (5 ml). After 2.5 h, the reaction mixture was poured into water, and extracted with ethyl acetate. The organic layer was washed with water, dried by Na_2SO_4, and evaporated. The residue was chromatographed on silica gel (hexane/ EtOAc 3:1) to afford product. Then took it (0.5 mmol) and 10% palladium on carbon (10%mol) in MeOH (6 ml) was stirred in a hydrogen atmosphere for 10 h. The reaction mixture was filtered, and the filtrate was evaporated to afford **3m**.

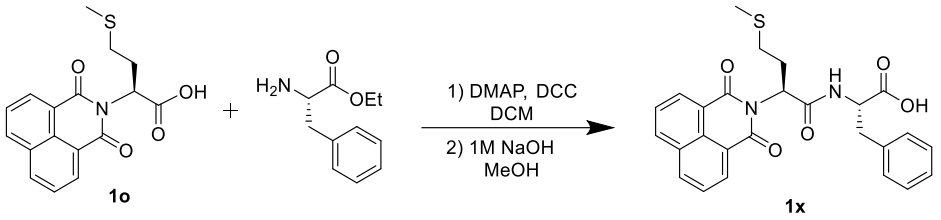
Preparation of **PAC-1w**:



A 50 mL Schlenk flask with a magnetic stirring bar was dried under vacuum with a heat gun. **PAC-1a** (0.40 mmol, 1.0 eq), H-Val-OEt·HCl (0.44 mmol, 1.1 eq), DMAP (0.04 mmol, 0.1 eq) and DCC (0.44 mmol, 1.1eq) were dissolved in 20 mL Dry DCM. The reaction mixture was stirred for 12 hours. The mixture was quenched by the addition of 8 mL brine and extracted with DCM (20 ml x 3). The organic layers were combined and concentrated under vacuo. The residue was chromatographed on silica gel (hexane/ EtOAc 2:1). Then it was dissolved in 10 mL MeOH. A solution of NaOH (1 M, 4ml) was added under vigorous stirring. After full conversion was indicated by TLC, MeOH was then removed at under vacuo. EtOAc (10 ml) was added, and the pH adjusted to 4 with HCl (1M). The mixture was poured into a separation funnel, the layers separated, and aqueous layer was extracted with EtOAc (10 ml x3). The combined organic extracts were washed

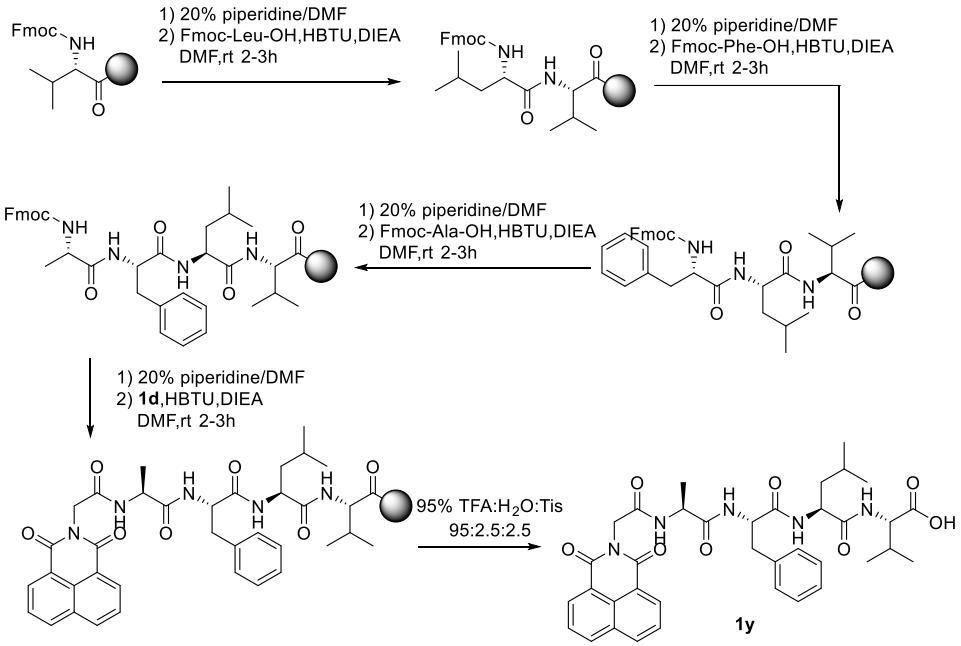
with brine (10 mL), dried by Na_2SO_4, and concentrated under reduced pressure to afford **1w**.

Preparation of **PAC-1x**:



A 50 mL Schlenk flask with a magnetic stirring bar was dried under vacuum with a heat gun. **PAC-1o** (0.40 mmol, 1.0 eq), H-Phe-OEt·HCl (0.44 mmol, 1.1 eq), DMAP (0.04 mmol, 0.1 eq) and DCC (0.44 mmol, 1.1eq) were dissolved in 20mL Dry DCM. The reaction mixture was stirred for 12 hours. The mixture was quenched by the addition of 8 mL brine and extracted with DCM (20 ml x 3). The organic layers were combined and concentrated under vacuo. The residue was chromatographed on silica gel (hexane/ EtOAc 2:1). Then it was dissolved in 10 mL MeOH. A solution of NaOH (1 M, 4ml) was added under vigorous stirring. After full conversion was indicated by TLC, MeOH was then removed at under vacuo. EtOAc (10 ml) was added, and the pH adjusted to 4 with HCl (1M). The mixture was poured into a separation funnel, the layers separated, and aqueous layer was extracted with EtOAc (10 ml x3). The combined organic extracts were washed with brine (10 mL), dried by Na_2SO_4, and concentrated under reduced pressure to afford **1x**.

Preparation of **PAC-1y**:

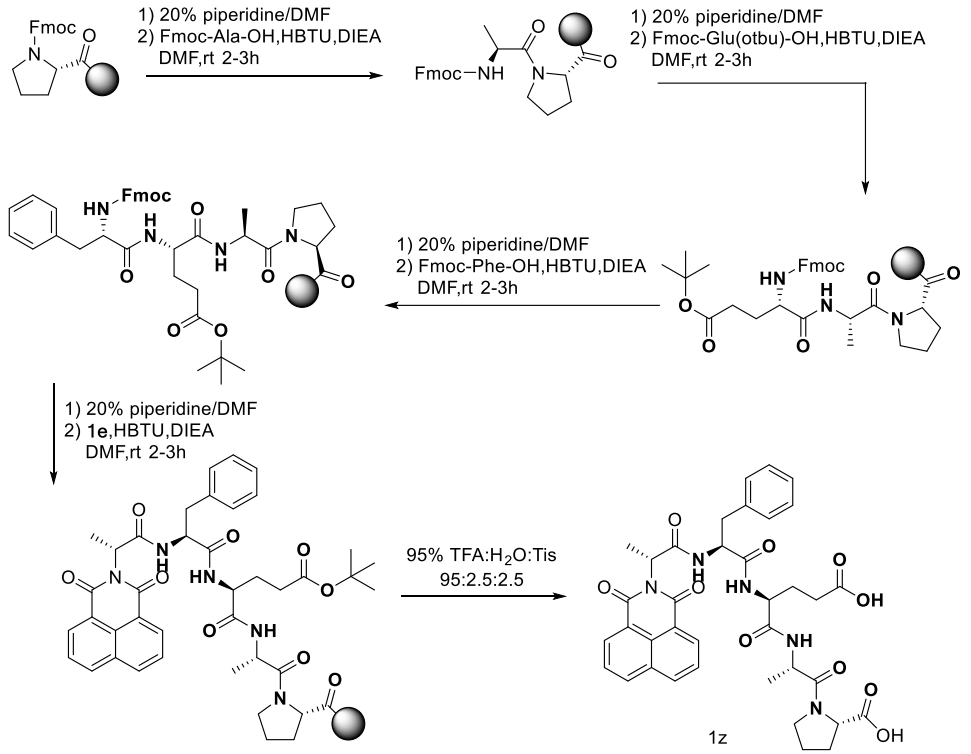


Weighed 5g (3mmol), Loading value 0.5g/mmol, Fmoc-Val-WangResin, DMF dissolved for 20min and then extracted DMF, added 20% piperidine, nitrogen drum blowing for 30min, extracted piperidine, washed with DMF for 6 times to drain the solvent, the ninhydrin color resin was blue-violet. Then added Fmoc-Leu-OH (9mmol, 3eq) HBTU (9mmol, 3eq) DIEA (18mmol, 6eq), reacted in DMF for 1h, washed with DMF for 3 times to extract the solvent, and the ninhydrin color resin was transparent. Added 20% piperidine, nitrogen blast for 30 min, extracted piperidine, washed with

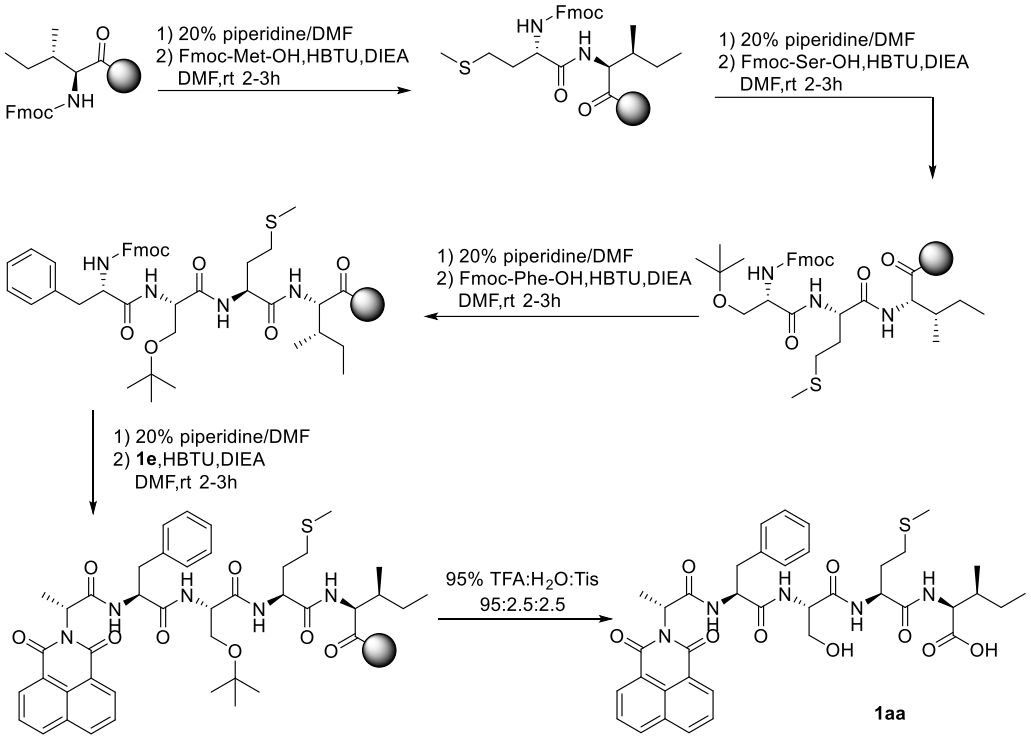
DMF 6 times and extracted dry, ninhydrin color resin was blue-violet. Added Fmoc-Phe-OH (9mmol, 3eq) HBTU (9mmol, 3eq) DIEA (18mmol, 6eq), 1h reaction in DMF, then washed with DMF for 3 times to extract the solvent, ninhydrin color resin was transparent. Added 20% piperidine, nitrogen blast for 30 min. extracted piperidine, washed with DMF 6 times to extracted dry, ninhydrin color resin was blue-violet. Added Fmoc-Ala-OH (9mmol, 3eq) HBTU (9mmol, 3eq) DIEA (18mmol, 6eq), reaction in DMF for 1h, then washed with DMF for 3 times to extract the solvent, ninhydrin color check resin was transparent, added 20% piperidine, nitrogen blast for 30min. extracted piperidine, washed 6 times to extract dry with DMF, ninhydrin color resin was blue-violet. Added **PAC-1d** (9mmol, 3eq) HBTU (9mmol, 3eq) DIEA (18mmol, 6eq), reacted in DMF for 1h, then washed with DMF for 3 times, ninhydrin color resin was transparent. Washed with methanol 3 times and extracted the resin. Added the resin from the above step to 95% lysate and stir magnetically for 2 h. Extracted the lysate and discard the resin. Added the lysate to ice ether at a ratio of 1:10 by volume to ice ether. A large amount of white precipitate was precipitated, and the precipitate was collected by centrifugation and dried to obtain **1y**.

The substrates **1z** and **1aa** were also synthesized by this procedure.

Preparation of **PAC-1z**:

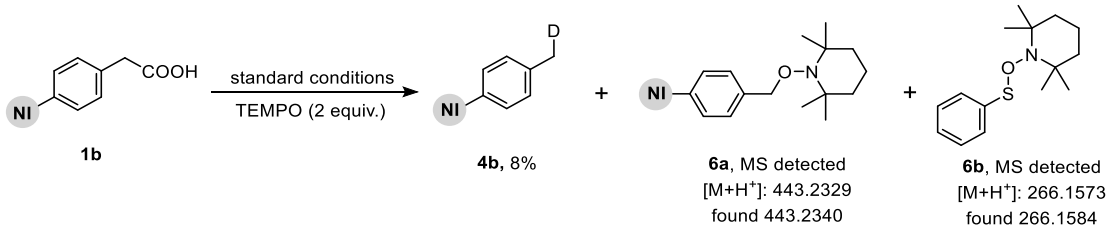


Preparation of **PAC-1aa**:



4. Mechanistic Investigations

4.1 TEMPO trap experiment

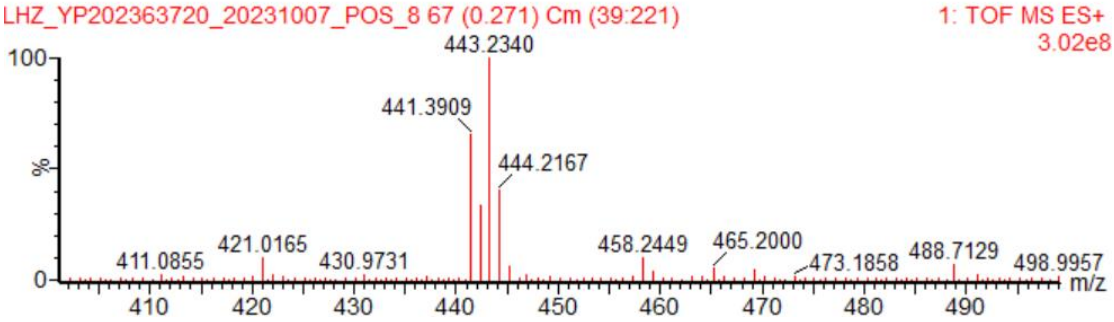


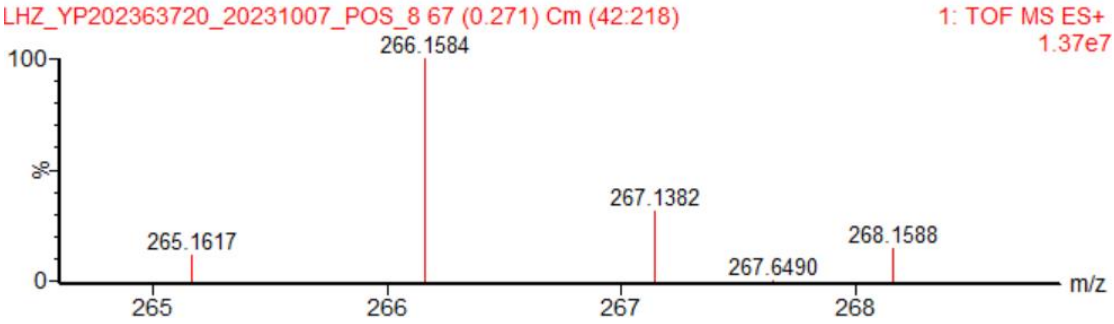
1b

4b, 8%

6a, MS detected
[M+H$^+$]: 443.2329
found 443.2340

6b, MS detected
[M+H$^+$]: 266.1573
found 266.1584

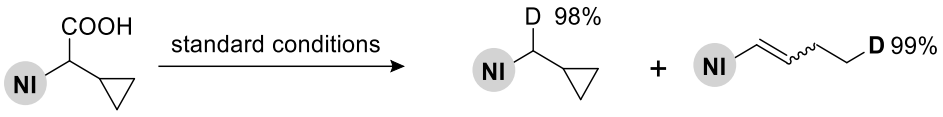




An oven-dried Schlenk tube (10 mL) was equipped with a magnetic stir bar, PAC **1b** (1 equiv., 0.1 mmol) and TEMPO (0.2 mmol, 2.0 eq), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 1.6 mL THF, 0.4 mL D_2O, and cesium hydroxide solution (2 equiv., 0.2 mmol) were added successively with syringe under N_2. The tube was then sealed and was stirred under the irradiation with blue LEDs at room temperature for 3 d. After the reaction was finished, the reaction mixture was extracted by ethyl acetate, dried by anhydrous Na_2SO_4, filtered and collected the organic layer. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product. Yield of product was determined by ^{1}H NMR analysis of the crude mixture using 1,3,5-Trimethoxybenzene as the internal standard.

The reaction was completely inhibited by TEMPO, the production of **6a** (HRMS-ESI: m/z Calculated for $C_{28}H_{31}N_2O_3^+$ [M+H$^+$]: 443.2329, found 443.2340) and **6b** (HRMS-ESI: m/z Calculated for $C_{15}H_{24}NOS^+$ [M+H$^+$]: 266.1573, found 266.1584) proved the existence of benzyl radical and thiyl radical intermediates

4.2 Radical clock experiences



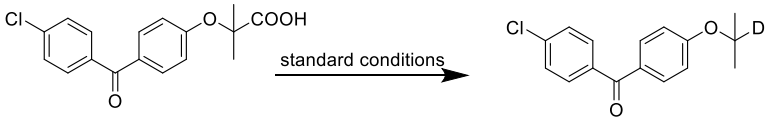
1ff **6c**, 44% **6d**, 7%

An oven-dried Schlenk tube (10 mL) was equipped with a magnetic stir bar, **PAC-1ff** (1 equiv., 0.1 mmol), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 1.6 mL THF, 0.4 mL D_2O, and cesium hydroxide solution (2 equiv., 0.2 mmol) were added successively with syringe under N_2. The tube was then sealed and was stirred under the irradiation with blue LEDs at room temperature for 3 d. After the reaction was finished, the reaction mixture was extracted by ethyl acetate, dried by anhydrous Na_2SO_4, filtered and collected the organic layer. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product. Yield of product was determined by ^1H NMR analysis of the crude mixture using 1,3,5-Trimethoxybenzene as the internal standard.

Compound **6c** was obtained in 44% yield as a withe powder with 98% D-incorporation, and compound **6d** was obtained in 7% yield as a withe powder with 99% D-incorporation. They proved the PACs could decarboxylate to generate alkyl radicals.

4.3 Bimolecular experiment

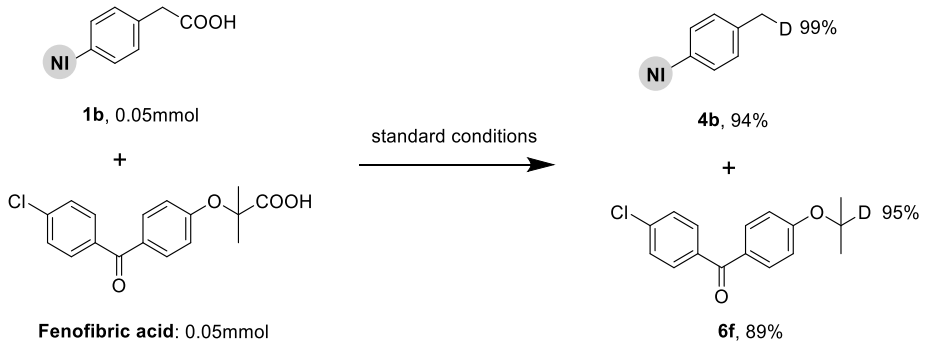
A-1:



Fenofibric acid: 0.05mmol N.D.

An oven-dried Schlenk tube (10 mL) was equipped with a magnetic stir bar, fenofibric acid (1 equiv., 0.1 mmol), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 1.6 mL THF, 0.4 mL D_2O, and cesium hydroxide solution (2 equiv., 0.2 mmol) were added successively with syringe under N_2. The tube was then sealed and was stirred under the irradiation with blue LEDs at room temperature for 3 d. We found no product formation.

A-2:

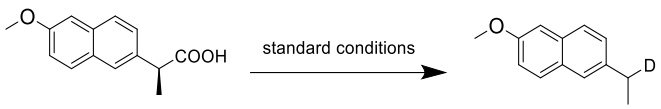


An oven-dried Schlenk tube (10 mL) was equipped with a magnetic stir bar, carboxylic acid **1b** (0.5 equiv., 0.05 mmol), Fenofibric acid (0.5 equiv., 0.05 mmol), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 1.6 mL THF, 0.4 mL D_2O, and cesium hydroxide solution (2 equiv., 0.2 mmol) were added successively with syringe under N_2. The tube was then

sealed and was stirred under the irradiation with blue LEDs at room temperature for 3 d. After the reaction was finished, the reaction mixture was extracted by ethyl acetate, dried by anhydrous Na_2SO_4, filtered and collected the organic layer. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product. Yield of product was determined by ^1H NMR analysis of the crude mixture using 1,3,5-Trimethoxybenzene as the internal standard.

Compound **4b** was obtained in 94% yield as a withe powder with 99% D-incorporation, **6f** was obtained in 89% yield as a withe powder with 95% D-incorporation, proves that a bimolecular catalytic reaction took place.

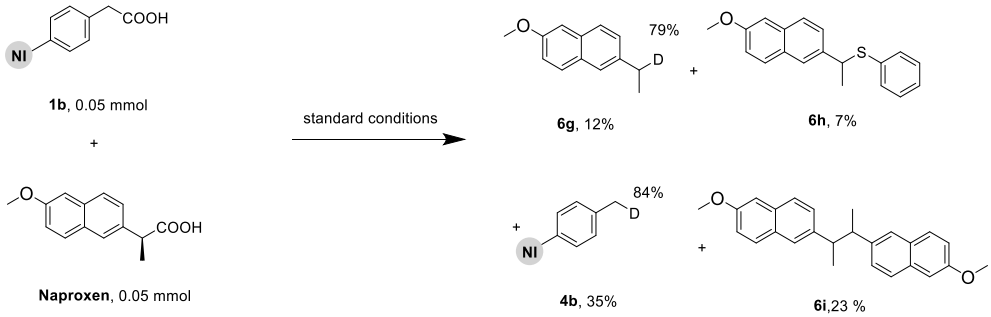
B-1:



Naproxen, 0.05 mmol N.D.

An oven-dried Schlenk tube (10 mL) was equipped with a magnetic stir bar, Naproxen acid (1 equiv., 0.1 mmol), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 1.6 mL THF, 0.4 mL D_2O, and cesium hydroxide solution (2 equiv., 0.2 mmol) were added successively with syringe under N_2. The tube was then sealed and was stirred under the irradiation with blue LEDs at room temperature for 3 d. We found no product formation.

B-2:



An oven-dried Schlenk tube (10 mL) was equipped with a magnetic stir bar, carboxylic acid **1b** (0.5 equiv., 0.05 mmol), Naproxen acid (0.5 equiv., 0.05 mmol), PhSNa (10 mol%). The flask was evacuated and backfilled with N_2 for 3 times. 1.6 mL THF, 0.4 mL D_2O, and cesium hydroxide solution (2 equiv., 0.2 mmol) were added successively with syringe under N_2. The tube was then sealed and was stirred under the irradiation with blue LEDs at room temperature for 3 d. After the reaction was finished, the reaction mixture was extracted by ethyl acetate, dried by anhydrous Na_2SO_4, filtered and collected the organic layer. The organic solvent was removed under the reduced pressure. The residue was purified by column chromatography on silica gel to obtain the desired product. Yield of product was determined by ^1H NMR analysis of the crude mixture using 1,3,5-Trimethoxybenzene as the internal standard.

Compound **4b** was obtained in 35% yield with 84% D-incorporation, **6g** was obtained in 12% yield with 79% D-incorporation, **6h** was obtained in 7% yield, and compound **6i** was obtained in 23% yield. Compound **6h** provides some proof for the thiophenol radical intermediate. And due to the trapping of the thiophenol radical by the benzyl radical, which leads to a decrease in the reaction

product and an increase in the double radical-couple byproduct **6i**.

4.4 UV-vis absorption spectroscopic measurements

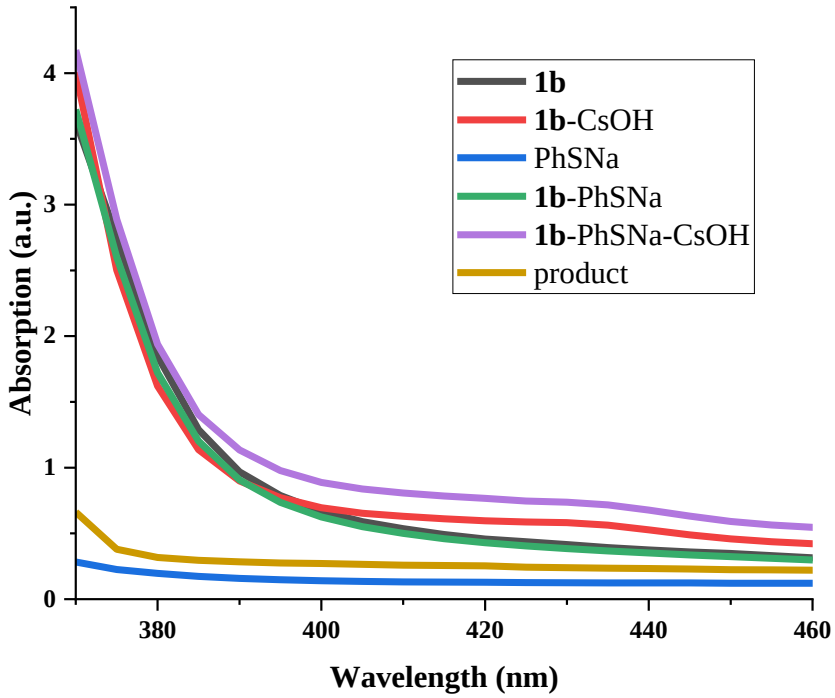


Figure S1. The UV-Vis spectrum of the **1b**

4.5 Cyclic voltammetry (CV)

Cyclic Voltammetry were collected using CHI 760E from Shanghai Chenhua Instruments Limited (SCHI). Sample (0.001 M) and tetrabutylammonium hexafluorophosphate (0.1 M) in anhydrous DMSO were used for tests. Measurements were run using glassy carbon working electrode, platinum wire counter electrode, and 0.01 M AgNO3 silver-silver chloride reference electrode in a scan rate of 0.1 V/s.

4.6 Mechanistic hypothesis

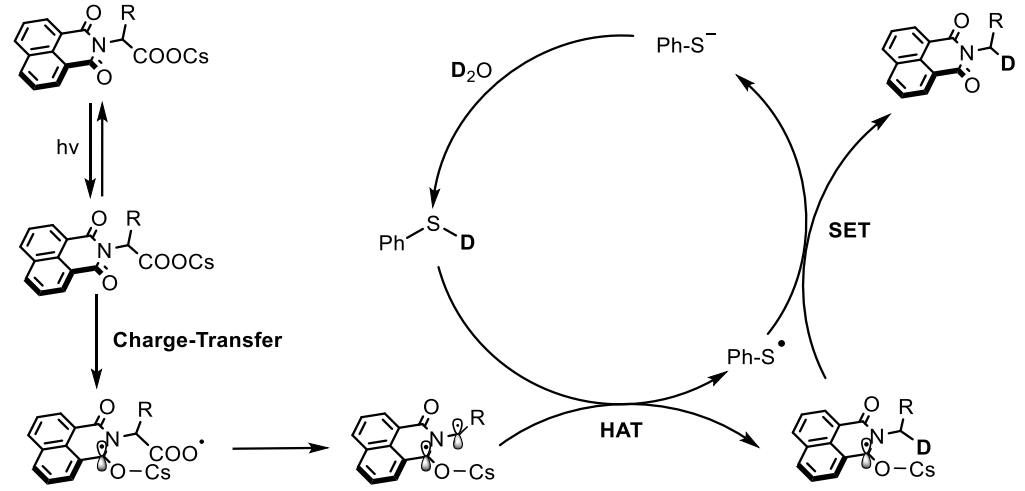


Figure S2. Monomolecular reaction mechanistic hypothesis

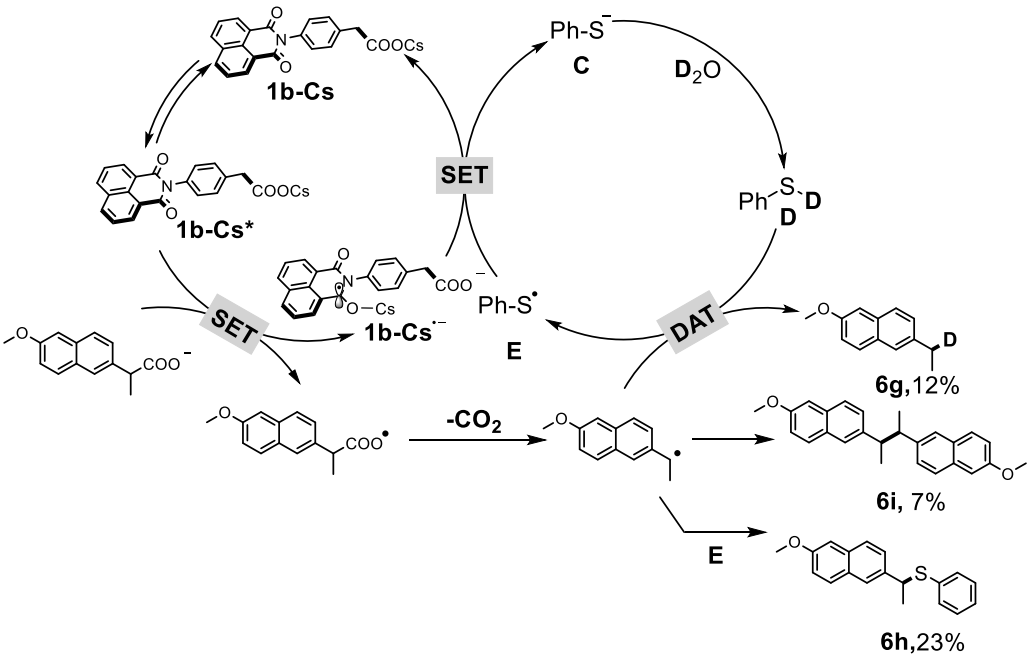


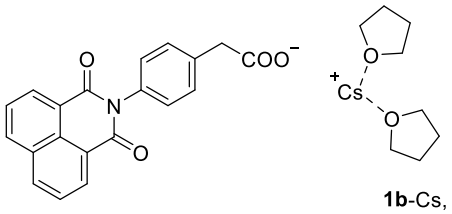
Figure S3. Bimolecular reaction mechanistic hypothesis

5. DFT Calculations

Computational methods

All the calculations were carried out by the Gaussian16 package[3]. The M06-2X hybrid functional[4] was applied for all calculations. For geometry optimization, the mixed basis set of SDD for Cs and 6-311+G(d) for other atoms with SMD[5] continuum solvent model for TetraHydroFuran were used. Analytical frequency calculations were performed at the same level of theory as the geometry optimization to identify the nature of all the stationary points being the minimum (no imaginary frequency) and to gain the Gibbs free energy corrections at 298.15 K. The final and solvation energies for the fully optimized structures in the TetraHydroFuran were calculated by employing the SMD[5] continuum solvation model with the larger mixed basis set (BS2) of SDD for Cs and 6-311+G(2df,2pd) for other atoms[3-5]. Then, the Multiwfn package is implemented to analyze the spin density distribution[6].

Cartesian coordinates and energies of the species



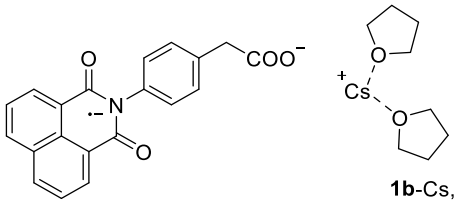
1b-Cs, T_1

Total electronic energy = -1610.0157512

Thermal corrections to Gibbs free energy = 0.434625

C	3.67501100	2.07624800	0.76438800
C	4.47331100	0.91167600	0.99999900
C	3.89862400	-0.36646300	1.00816600
C	2.48091600	-0.48114000	0.77834300
C	1.71610100	0.67465000	0.55980800
C	2.33675000	1.97540700	0.54905200
C	4.63530000	-1.54082500	1.23328900
C	3.99722200	-2.82252500	1.22870000
C	2.66216100	-2.93944000	1.00593500
C	1.87663600	-1.74916600	0.77573000
C	0.43795000	-1.88424700	0.56689200
N	-0.28636700	-0.70230300	0.38915200
C	0.26996000	0.58124700	0.35380100
O	-0.42916600	1.56397400	0.16989900
O	-0.12042000	-2.97282200	0.56595900
C	-1.72180700	-0.81146500	0.31676400
C	-2.34090600	-1.21762200	-0.85749200
C	-3.72321900	-1.37980500	-0.87737300
C	-4.49387500	-1.14595100	0.26640700
C	-3.84844600	-0.70398100	1.42646300
C	-2.46960500	-0.53671100	1.45436500

C	-5.94300300	-1.54475900	0.30747300
C	-5.93399400	-3.03781300	0.74929400
O	-5.81674700	-3.88132500	-0.16807600
O	-5.92509600	-3.25229000	1.97951500
H	4.15613800	3.04764700	0.76095200
H	5.53835800	1.01660200	1.17357600
H	1.71790300	2.84466800	0.36921700
H	5.70215900	-1.47204000	1.41252700
H	4.59903200	-3.70638700	1.40761700
H	2.16394300	-3.89994400	0.99469200
H	-1.74309200	-1.42956300	-1.73808600
H	-4.20995400	-1.72212600	-1.78451600
H	-4.43058700	-0.52220200	2.32420900
H	-1.96606500	-0.21286400	2.35906100
H	-6.49086200	-0.94386100	1.03422700
H	-6.40059900	-1.44935200	-0.67795900
Cs	-2.89236900	-4.15448700	1.21504700
C	-1.59153800	-5.87570000	-2.51439700
O	-2.39917900	-5.11842000	-1.62244200
C	-3.45384600	-4.59252500	-2.42545200
C	-3.86909100	-5.75536200	-3.33140200
C	-2.57425400	-6.59472100	-3.45273300
H	-0.94023400	-5.19451700	-3.07758700
H	-0.96853300	-6.54530600	-1.92089700
H	-4.24569500	-4.23644800	-1.76392400
H	-3.06675400	-3.75379500	-3.02143400
H	-4.66259600	-6.33398000	-2.85571200
H	-4.23894700	-5.40473000	-4.29559000
H	-2.74330300	-7.62178500	-3.12654600
H	-2.19193200	-6.62720900	-4.47371000
C	-2.24189200	-2.29154800	4.54250000
O	-1.41635500	-2.76855300	3.48581200
C	-0.11017700	-2.25445400	3.73332900
C	0.02656100	-2.11899500	5.26579700
C	-1.38282100	-2.45915400	5.78981000
H	-2.48953400	-1.23390500	4.37618700
H	-3.16474700	-2.87383200	4.54475300
H	0.60653800	-2.94510100	3.28768600
H	-0.00616400	-1.27636700	3.24407100
H	0.78067000	-2.79703800	5.66603200
H	0.31510900	-1.10198200	5.53552900
H	-1.42930700	-3.49573200	6.12999500
H	-1.70171900	-1.81355500	6.60867400



1b-Cs, radical anion

Total electronic energy = -1610.2140026

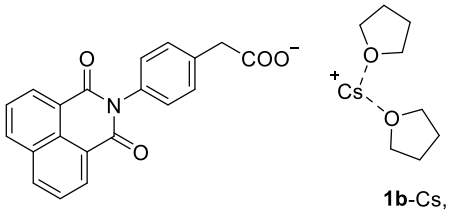
Thermal corrections to Gibbs free energy = 0.436396

C	3.65995500	2.01551500	0.78904800
C	4.43814200	0.87106000	0.95966900
C	3.85424300	-0.41723100	0.94295600
C	2.43440900	-0.52331700	0.74582200
C	1.66746500	0.65526000	0.58269700
C	2.28888800	1.92077200	0.60172400
C	4.60441000	-1.60635100	1.11375000
C	3.98411300	-2.85557900	1.09025100
C	2.61566700	-2.96795200	0.89545900
C	1.83037800	-1.80648200	0.72016800
C	0.40348100	-1.92958600	0.54268900
N	-0.31468300	-0.72729200	0.40455000
C	0.23061400	0.56923500	0.40282500
O	-0.50838500	1.54267800	0.25901700
O	-0.20268400	-3.00759500	0.52590400
C	-1.74589300	-0.83349100	0.32817100
C	-2.36294400	-1.25430400	-0.84307400
C	-3.74473400	-1.42081900	-0.87298800
C	-4.52606100	-1.17452400	0.26050800
C	-3.88875700	-0.71311600	1.41704100
C	-2.50949000	-0.54349400	1.45209100
C	-5.97571400	-1.57674800	0.29390000
C	-5.98044500	-3.06499600	0.74927900
O	-5.84388100	-3.91783400	-0.15716300
O	-6.00957800	-3.26990400	1.98127500
H	4.13411600	2.99188400	0.80469000
H	5.51047400	0.95639700	1.10801300
H	1.67738100	2.80561200	0.47121000
H	5.67688000	-1.53021700	1.26510400
H	4.58188700	-3.75184000	1.22461300
H	2.12914700	-3.93585600	0.87243900
H	-1.75823400	-1.47532900	-1.71671700
H	-4.22303300	-1.77842800	-1.77915200
H	-4.47702900	-0.51770100	2.30841000
H	-2.01628100	-0.20064000	2.35500800
H	-6.53115400	-0.96684100	1.00769400
H	-6.42423400	-1.48990500	-0.69695000

Cs	-2.90736100	-4.13163400	1.27937400
C	-1.57207900	-5.95447700	-2.36115200
O	-2.50966100	-5.32789300	-1.49531600
C	-3.42427300	-4.65317100	-2.35506000
C	-3.70780800	-5.65896200	-3.47176700
C	-2.38764800	-6.46046300	-3.56536400
H	-0.82421200	-5.21569500	-2.67663800
H	-1.06946700	-6.74346700	-1.80127900
H	-4.29637100	-4.36465300	-1.76533500
H	-2.93997300	-3.75265700	-2.75898200
H	-4.53612300	-6.30913600	-3.18477300
H	-3.97296500	-5.16581600	-4.40779200
H	-2.57311000	-7.53291100	-3.49335800
H	-1.85805800	-6.27572000	-4.50098000
C	-2.24516200	-2.15884200	4.67043500
O	-1.51216400	-2.77410700	3.62031300
C	-0.18001500	-2.27982700	3.73624300
C	0.08366100	-2.11805500	5.24689600
C	-1.31912800	-2.24680200	5.88190800
H	-2.45366900	-1.11052900	4.41500700
H	-3.19243800	-2.68840000	4.78259300
H	0.48295800	-2.98681800	3.23822400
H	-0.10681800	-1.31249400	3.22210500
H	0.76037000	-2.88808200	5.61878200
H	0.53727300	-1.14825900	5.45561900
H	-1.43622100	-3.21805800	6.36662800
H	-1.52642600	-1.47018900	6.61910600

Excited State Calculation

The vertical excitation energies of excited singlet (Sn) and triplet states (Tn) were determined at M06-2X/ mixed basis set of SDD for Cs and 6-311+G(2df, 2pd) level using TD-DFT method. The first 5 excited states of PAC-**1b** were reported below, which correspond to their vertical excitation energies. Among the vertical excitation energies below the S_1 state where the T_1 as well as the T_2 state. The free energy of second triplet state (T_2) were estimated by considering the vertical excitation energy between T_2 and the lowest triplet state (T_1).



1b-Cs, T_n

C	3.71994	2.05774	0.75222
C	4.48707	0.94068	0.9741
C	3.90005	-0.34997	0.98645

C	2.50443	-0.46749	0.76779
C	1.73278	0.69697	0.54514
C	2.33203	1.93595	0.53632
C	4.65711	-1.52738	1.21154
C	4.05365	-2.761	1.21413
C	2.66587	-2.87331	0.99358
C	1.90355	-1.74819	0.77462
C	0.44289	-1.88476	0.57524
N	-0.28134	-0.69984	0.39165
C	0.26889	0.59219	0.33808
O	-0.44067	1.55266	0.14465
O	-0.12197	-2.9583	0.58563
C	-1.71736	-0.81241	0.32306
C	-2.33933	-1.21187	-0.85214
C	-3.72167	-1.37349	-0.87016
C	-4.48997	-1.14568	0.27647
C	-3.84177	-0.71245	1.43824
C	-2.46273	-0.54578	1.4641
C	-5.93998	-1.54167	0.317
C	-5.93401	-3.03724	0.74948
O	-5.81588	-3.87531	-0.17288
O	-5.92751	-3.25949	1.97833
H	4.17595	3.04068	0.74294
H	5.55549	1.03009	1.14346
H	1.72598	2.81781	0.36304
H	5.72519	-1.43606	1.38212
H	4.63964	-3.65578	1.38812
H	2.18848	-3.84656	0.99616
H	-1.74364	-1.41799	-1.7356
H	-4.2105	-1.70988	-1.77842
H	-4.42174	-0.5366	2.33859
H	-1.95693	-0.22832	2.36982
H	-6.48559	-0.94403	1.0481
H	-6.39848	-1.4391	-0.66731
Cs	-2.90128	-4.16557	1.20917
C	-1.58793	-5.87876	-2.51986
O	-2.38543	-5.11029	-1.62839
C	-3.44352	-4.58575	-2.4282
C	-3.86823	-5.7515	-3.32667
C	-2.58151	-6.60436	-3.4407
H	-0.94009	-5.20524	-3.09616
H	-0.96129	-6.54404	-1.9253
H	-4.23108	-4.22464	-1.7642
H	-3.05773	-3.75058	-3.02979

H	-4.66832	-6.31926	-2.84901
H	-4.23292	-5.40355	-4.29376
H	-2.75793	-7.62372	-3.09477
H	-2.20476	-6.65881	-4.4628
C	-2.27367	-2.29932	4.55474
O	-1.45515	-2.79063	3.4992
C	-0.13999	-2.2976	3.74338
C	-0.0049	-2.14082	5.27409
C	-1.41468	-2.4726	5.80093
H	-2.5087	-1.23936	4.38485
H	-3.20335	-2.87058	4.55984
H	0.56462	-3.00804	3.3103
H	-0.015	-1.32968	3.23915
H	0.74953	-2.81204	5.68501
H	0.28195	-1.1196	5.52962
H	-1.46713	-3.50922	6.14035
H	-1.72791	-1.82536	6.62069

Excited State	1:	Triplet-A	2.7247 eV	455.04 nm	f=0.0000	<S**2>=2.000
Excited State	2:	Triplet-A	3.6773 eV	337.16 nm	f=0.0000	<S**2>=2.000
Excited State	3:	Singlet-A	3.9970 eV	310.19 nm	f=0.3764	<S**2>=0.000
Excited State	4:	Triplet-A	4.0917 eV	303.01 nm	f=0.0000	<S**2>=2.000
Excited State	5:	Triplet-A	4.1131 eV	301.44 nm	f=0.0000	<S**2>=2.000

Reduction Potential (E) Calculations

$$[\textbf{1b-cs}]^{*} + \text{e-} \longrightarrow [\textbf{1b-Cs}]^{\cdot -}$$

$$\textbf{E(vs SCE)} = -(\Delta G/F) - E_{SHE} - E_{SCE}\textbf{(vs SHE)}$$

Where ΔG is the standard free energy for the reaction, F is the Faraday constant, E_{SHE} is the absolute potential of standard hydrogen electrode (4.28 V) and E_{SCE}(vs SHE) is the potential of saturated calomel electrode vs SHE (0.24 V). Thus, the reduction potential of [**1b**-Cs]***** is 0.82-1.77V vs SCE.

Table S4. Computed reduction potential for PAC-**1b** excited Tn states

Entry	ΔE_T@T_n (eV)	E_0@Tn (Hatree)	G_{corr}@Tn (Hatree)	E_0@RA (Hatree)	G_{corr}@RA (Hatree)	$E^0_{(A^*/A^{\bullet -})}$ (V vs. SCE)
1b-T_1	2.7247	-1610.015751	0.434625	-1610.214003	0.436396	0.82
1b-T_2	3.6773	-1609.980742	0.434625	-1610.214003	0.436396	1.77

ΔET@Tn: vertical transition energies for excited Tn state; E_0@T_n: Total electronic energy for excited Tn state; G_{corr}@T_n: correction to the Gibbs free energy for excited Tn state; E_0@RA: Total electronic energy for radical anion; G_{corr}@RA: correction to the Gibbs free energy for radical anion; $E^0_{(A^*/A^{\bullet -})}$: standard reduction potentials for PAC-**1b** between T_n state and radical anion.

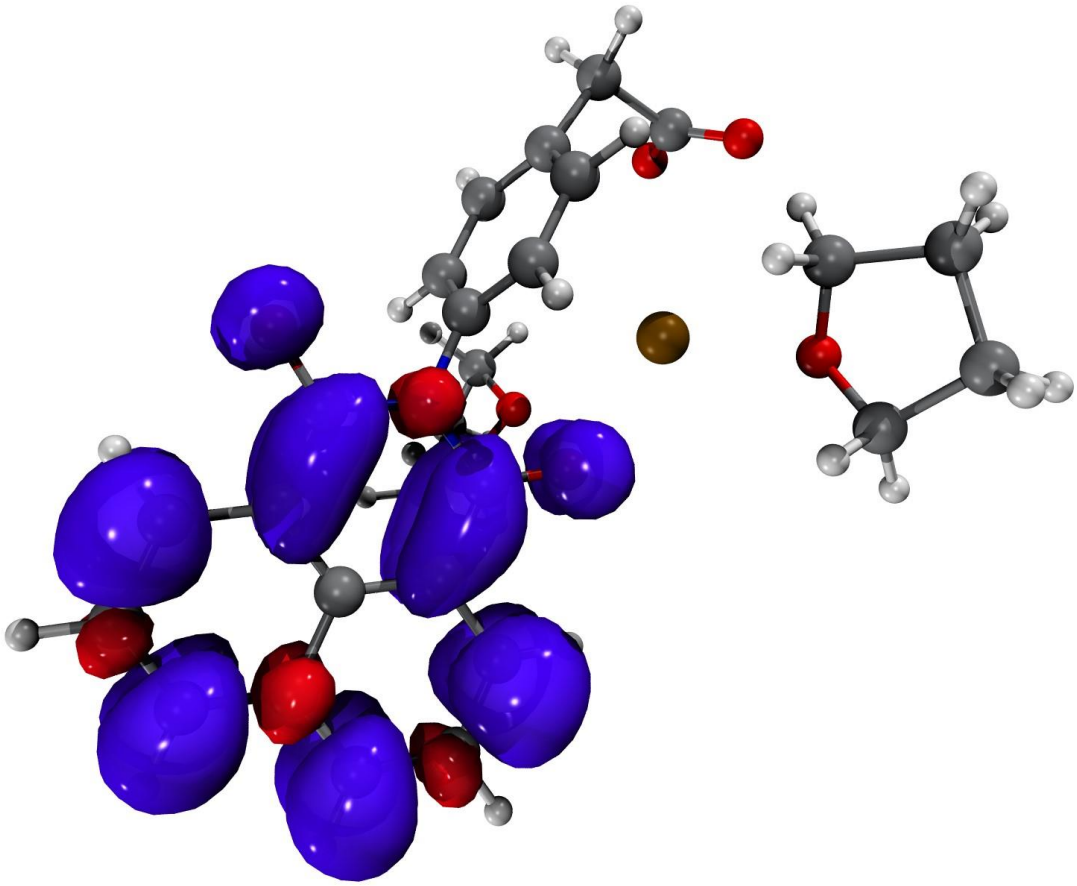
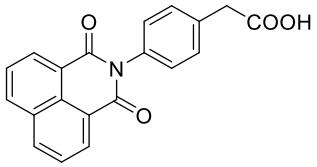


Figure S4. The spin density distribution of the [**1b**-Cs]˙⁻

6. Characterization of Compounds.

6.1 Characterization of PACs.

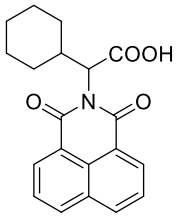


2-(4-(1,3-dioxo-1H-benzo[*de*]isoquinolin-2(3*H*)-yl) phenyl) acetic acid (1b)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.65 (d, *J* = 7.3 Hz, 2H), 8.27 (d, *J* = 8.3 Hz, 2H), 7.79 (t, *J* = 7.8 Hz, 2H), 7.51 (d, *J* = 8.2 Hz, 2H), 7.30 (d, *J* = 6.1 Hz, 2H), 3.75 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 175.7, 164.4, 134.5, 134.3, 134.0, 131.8, 131.7, 130.5, 128.9, 128.6, 127.1, 122.8, 40.7.

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{14}NO_4^+$ $[M+H]^+$ 332.0917; found 332.0931.

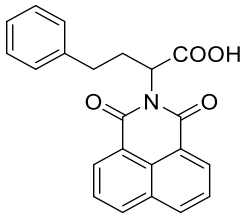


2-cyclohexyl-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) acetic acid (1j)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.67 – 8.63 (m, 4H), 8.05 – 8.01 (m, 2H), 5.33 (d, *J* = 8.9 Hz, 1H), 2.54 – 2.47 (m, 2H), 1.82 (d, *J* = 12.8 Hz, 1H), 1.68 (m, 2H), 1.41 (d, *J* = 12.5 Hz, 2H), 1.23 – 1.15 (m, 3H), 0.96-0.91 (m, 1H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 171.1, 163.8, 135.4, 132.0, 131.8, 128.0, 127.9, 121.7, 57.3, 36.4, 33.1, 28.7, 26.3, 26.0, 25.9.

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{19}KNO_4^+$ $[M+K]^+$ 376.0946; found 376.0945.

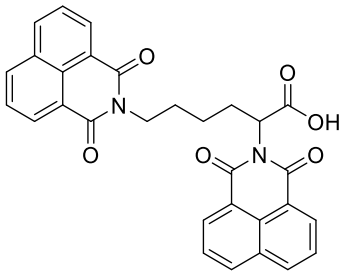


2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-4-phenylbutanoic acid (1m)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.50 (dd, *J* = 13.1, 7.8 Hz, 4H), 7.89 (t, *J* = 7.8 Hz, 2H), 7.15 – 7.09 (m, 4H), 7.13 – 7.09 (m, 1H), 5.61 (dd, *J* = 9.3, 4.3 Hz, 1H), 2.72 – 2.65 (m, 1H), 2.61 – 2.51 (m, 2H), 2.44 – 2.36 (m, 1H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 171.0, 163.3, 141.2, 134.7, 131.3, 131.2, 128.1, 128.1, 127.5, 127.3, 125.6, 121.7, 52.8, 32.2, 29.9.

HRMS (ESI-TOF, m/z): calcd for $C_{22}H_{18}NO_4^+$ [M+H]$^+$ 360.1230; found 360.1258.

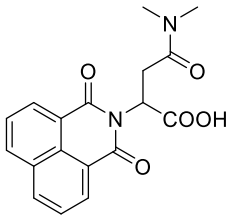


2,6-bis(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) hexanoic acid (1n)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.46 (d, *J* = 8.2 Hz, 2H), 8.39 (d, *J* = 8.1 Hz, 2H), 8.36 (d, *J* = 7.2 Hz, 2H), 8.23 (d, *J* = 7.2 Hz, 2H), 7.82 (t, *J* = 7.7 Hz, 2H), 7.76 (t, *J* = 7.7 Hz, 2H), 5.49 (dd, *J* = 9.6, 4.8 Hz, 1H), 4.02 – 3.94 (m, *J* = 14.9, 6.1 Hz, 2H), 2.29 – 2.21 (m, 1H), 2.19 – 2.12 (m, 1H), 1.74 – 1.57 (m, 2H), 1.39 – 1.22 (m, 2H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 171.1, 163.4, 163.2, 134.7, 134.2, 131.3, 131.2, 131.2, 130.5, 127.4, 127.3, 127.2, 127.1, 121.9, 121.5, 52.8, 40.1, 27.9, 27.2, 23.5.

HRMS (ESI-TOF, m/z): calcd for $C_{30}H_{22}N_2NaO_6^+$ [M+Na]$^+$ 529.1370; found 529.1384.

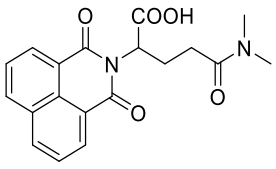


4-(dimethylamino)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-4-oxobutanoic acid (1p)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.51 (dd, *J* = 14.4, 7.8 Hz, 4H), 7.91 – 7.89 (m, 2H), 6.17 (dd, *J* = 7.7, 4.6 Hz, 1H), 3.50 (d, *J* = 7.8 Hz, 1H), 2.97 (s, 3H), 2.81 (s, 3H), 2.72 (dd, *J* = 16.5, 4.7 Hz, 1H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 170.9, 169.5, 163.2, 134.7, 131.3, 131.1, 127.4, 127.4, 121.8, 49.6, 36.5, 35.0, 33.0.

HRMS (ESI-TOF, m/z): calcd for $C_{18}H_{16}N_2NaO_5^+$ [M+Na]$^+$ 363.0951; found 363.0971.

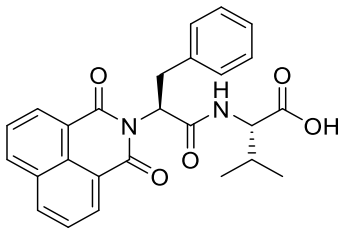


5-(dimethylamino)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-5-oxopentanoic acid (1q)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.51 (dd, *J* = 12.2, 7.7 Hz, 4H), 7.90 (t, *J* = 7.7 Hz, 2H), 5.55 (dd, *J* = 9.2, 4.5 Hz, 1H), 2.80 (s, 3H), 2.59 (s, 3H), 2.49 – 2.44 (m, 1H), 2.38 – 2.27 (m, 3H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 171.2, 171.0, 163.4, 134.6, 131.3, 131.1, 127.5, 127.4, 121.9, 52.7, 36.5, 34.7, 29.1, 23.8.

HRMS (ESI-TOF, m/z): calcd for $C_{19}H_{18}N_2NaO_5^+$ [M+Na]$^+$ 377.1108; found 377.1142.

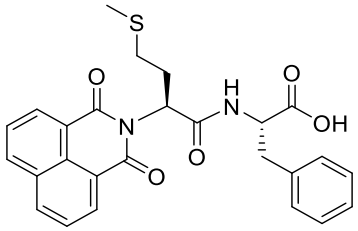


((S)-2-(1,3-dioxo-1H-benzo[de]isoquinolin-2(3H)-yl)-3-phenylpropanoyl)-L-valine (1w)

^{1}H NMR (600 MHz, DMSO-*d*$_6$) δ 8.45 – 8.37 (m, 4H), 8.20 (d, *J* = 8.4 Hz, 1H), 7.82 (t, *J* = 7.7 Hz, 2H), 7.11 (d, *J* = 8.0 Hz, 2H), 7.05 (t, *J* = 7.6 Hz, 2H), 6.99 (t, *J* = 7.2 Hz, 1H), 5.76 (dd, *J* = 9.6, 5.6 Hz, 1H), 4.22 – 4.17 (m, 1H), 3.66 (dd, *J* = 14.0, 5.6 Hz, 1H), 3.27 (dd, *J* = 14.0, 9.6 Hz, 1H), 1.91 (h, *J* = 6.8 Hz, 1H), 0.84 (d, *J* = 6.8 Hz, 3H), 0.71 (d, *J* = 6.7 Hz, 3H)..

^{13}C NMR (151 MHz, DMSO-*d*$_6$) δ 173.8, 169.0, 163.9, 138.9, 134.5, 131.7, 130.9, 129.6, 128.4, 128.0, 127.6, 126.5, 123.0, 58.5, 55.4, 34.9, 30.0, 19.8, 19.2.

HRMS (ESI-TOF, m/z): calcd for $C_{26}H_{24}N_2NaO_5^+$ [M+Na]$^+$ 467.1577; found 467.1571.

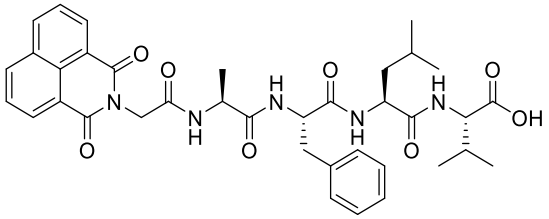


((*S*)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-4-(methylthio) butanoyl)-L-phenylalanine (1x)

^{1}H NMR (600 MHz, DMSO-*d*$_6$) δ 8.47 (dd, *J* = 12.3, 7.6 Hz, 4H), 7.91 (t, *J* = 7.7 Hz, 2H), 7.08 – 6.98 (m, 5H), 5.55 (dd, *J* = 8.6, 5.1 Hz, 1H), 4.30 (s, 1H), 2.87 (dd, *J* = 13.9, 4.7 Hz, 1H), 2.79 (dd, *J* = 13.8, 8.7 Hz, 1H), 2.61 – 2.53 (m, 1H), 2.46 (dd, *J* = 15.7, 7.2 Hz, 2H), 2.14 (dq, *J* = 14.9, 7.9 Hz, 1H), 1.97 (s, 3H).

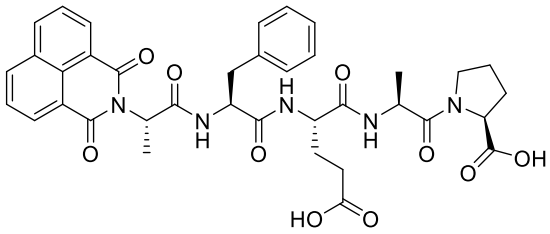
^{13}C NMR (151 MHz, DMSO-*d*$_6$) δ 173.7, 168.9, 164.0, 138.6, 134.7, 131.8, 131.3, 129.5, 128.2, 127.6, 126.4, 123.0, 70.3, 53.3, 36.7, 31.1, 28.2, 15.0.

HRMS (ESI-TOF, m/z): calcd for $C_{26}H_{24}N_2NaO_5S^+$ [M+Na]$^+$ 499.1298; found 499.1309.

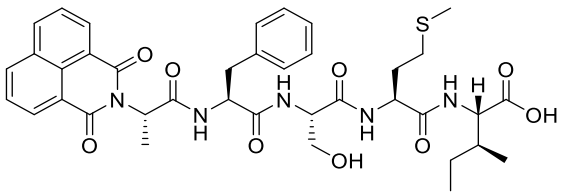


(2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) acetyl)-*L*-alanyl-*L*-phenylalanyl-*L*-leucyl-*L*-valine (1y)

^{1}H NMR (600 MHz, DMSO-d_6) δ 12.54 (s, 1H), 8.55 (d, *J* = 7.2 Hz, 1H), 8.51 (dd, *J* = 7.7, 1.9 Hz, 4H), 7.94 (d, *J* = 8.2 Hz, 1H), 7.92 – 7.89 (m, 2H), 7.86 (d, *J* = 8.3 Hz, 1H), 7.78 (d, *J* = 8.4 Hz, 1H), 7.28 – 7.22 (m, 4H), 7.19 – 7.15 (m, 1H), 4.76 – 4.67 (m, 2H), 4.51 – 4.45 (m, 1H), 4.33 (td, *J* = 8.9, 5.8 Hz, 1H), 4.27 (p, *J* = 7.1 Hz, 1H), 4.10 (dd, *J* = 8.4, 5.9 Hz, 1H), 3.08 (dd, *J* = 14.1, 4.4 Hz, 1H), 2.85 (dd, *J* = 14.0, 9.6 Hz, 1H), 2.03 (dq, *J* = 13.4, 6.7 Hz, 1H), 1.50 (dp, *J* = 13.3, 6.6 Hz, 1H), 1.43 – 1.34 (m, 2H), 1.16 (d, *J* = 7.1 Hz, 3H), 0.86 (dd, *J* = 6.8, 4.2 Hz, 6H), 0.72 (d, *J* = 6.6 Hz, 3H), 0.69 (d, *J* = 6.5 Hz, 3H).
^{13}C NMR (151 MHz, DMSO-d_6) δ 173.2, 172.4, 172.4, 171.0, 167.3, 163.9, 138.2, 135.1, 131.9, 131.4, 129.6, 128.6, 128.0, 127.8, 126.7, 122.4, 57.6, 54.4, 51.4, 49.0, 42.8, 41.2, 37.5, 30.3, 24.4, 23.4, 21.9, 19.5, 18.6, 18.5.
HRMS (ESI-TOF, m/z): calcd for $C_{37}H_{43}N_5NaO_8^+$ $[M+Na]^+$ 708.3004; found 708.3043.



((*S*)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) propanoyl)-*L*-phenylalanyl-*L*-glutamyl-*L*-alanyl-*L*-proline (1z)
^{1}H NMR (600 MHz, DMSO-d_6) δ 8.48 (d, *J* = 8.4 Hz, 2H), 8.43 (d, *J* = 8.4 Hz, 2H), 8.19 (d, *J* = 7.6 Hz, 1H), 8.01 (d, *J* = 7.0 Hz, 1H), 7.92 – 7.87 (m, 3H), 7.06 (d, *J* = 7.8 Hz, 3H), 7.03 – 6.98 (m, 2H), 5.40 (q, *J* = 6.9 Hz, 1H), 4.48 – 4.44 (m, 1H), 4.36 – 4.32 (m, 1H), 4.30 – 4.26 (m, 1H), 4.24 (dd, *J* = 8.7, 4.6 Hz, 1H), 3.66 – 3.62 (m, 1H), 3.52 – 3.48 (m, 1H), 2.92 (dd, *J* = 14.2, 3.9 Hz, 1H), 2.79 (dd, *J* = 14.1, 10.4 Hz, 1H), 2.37 – 2.26 (m, 2H), 2.17 – 2.11 (m, 1H), 1.96 – 1.88 (m, 3H), 1.85 – 1.78 (m, 2H), 1.46 (d, *J* = 6.9 Hz, 3H), 1.17 (d, *J* = 6.9 Hz, 3H).
^{13}C NMR (151 MHz, DMSO-d_6) δ 174.6, 173.6, 171.8, 170.9, 170.7, 169.9, 163.6, 138.8, 134.7, 131.7, 131.3, 129.4, 128.3, 128.1, 127.6, 126.3, 122.9, 58.9, 55.3, 52.2, 49.8, 46.8, 46.6, 36.4, 30.6, 29.0, 27.9, 25.0, 17.1, 14.6.
HRMS (ESI-TOF, m/z): calcd for $C_{37}H_{39}N_5NaO_{10}^+$ $[M+Na]^+$ 736.2589; found 736.2621.

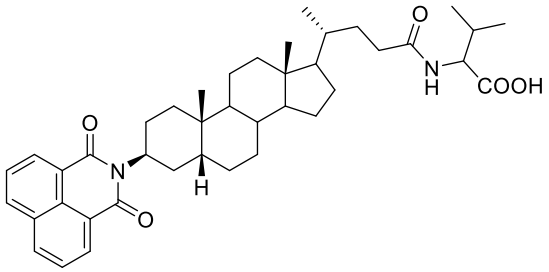


((*S*)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) propanoyl)-*L*-phenylalanyl-*L*-seryl-*L*-methionyl-*L*-isoleucine (1aa)
^{1}H NMR (600 MHz, DMSO-d_6) δ 8.48 (d, *J* = 8.3 Hz, 2H), 8.44 (d, *J* = 6.1 Hz, 2H), 8.19 (d, *J* = 7.5 Hz, 1H), 8.08 (d, *J* = 7.5 Hz, 1H), 7.94 – 7.89 (m, 4H), 7.09 – 7.05 (m, 3H), 6.99 (t, *J* = 7.6 Hz, 2H), 5.43 (q, *J* = 6.9 Hz, 1H), 4.47 – 4.40 (m, 2H), 4.34 – 4.28 (m, 1H), 4.13 (dd, *J* = 8.2, 5.9 Hz, 1H), 3.68 (dd, *J* = 10.7, 5.9 Hz, 1H), 3.61 (dd, *J* = 10.6, 5.7 Hz, 1H), 2.91 (dd, *J* = 14.4, 3.9 Hz, 1H), 2.77 (dd, *J* = 14.1, 10.3 Hz, 1H), 2.46 – 2.38 (m, 2H), 1.99 (s, 3H), 1.97 – 1.92 (m, 1H), 1.83 – 1.74 (m, 2H), 1.46 (d, *J* =

6.9 Hz, 3H), 1.43 – 1.37 (m, 1H), 1.22 – 1.14 (m, 1H), 0.86 – 0.80 (m, 6H).

^{13}C NMR (151 MHz, DMSO-*d*$_6$) δ 173.1, 172.2, 171.5, 170.4, 169.9, 163.5, 138.7, 134.7, 131.7, 131.3, 129.4, 128.2, 128.1, 127.6, 126.3, 122.9, 62.0, 56.9, 55.7, 55.2, 52.1, 49.8, 36.7, 36.6, 32.5, 29.8, 25.1, 16.0, 15.1, 14.6, 11.8.

HRMS (ESI-TOF, m/z): calcd for $C_{38}H_{46}N_5O_9S^+$ $[M+H]^+$ 748.3011; found 748.3009.

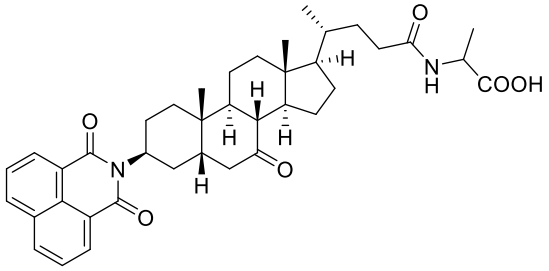


((4*R*)-4-((3*S*,5*R*,10*S*,13*R*)-3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-10,13-dimethylhexadecahydro-1*H*-cyclopenta[*a*]phenanthren-17-yl) pentanoyl) valine (1bb)

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.58 (d, *J* = 7.3 Hz, 2H), 8.18 (d, *J* = 8.2 Hz, 2H), 7.74 (t, *J* = 7.7 Hz, 2H), 5.91 (d, *J* = 8.4 Hz, 1H), 5.30 – 5.25 (m, 1H), 4.56 (dd, *J* = 8.5, 5.0 Hz, 1H), 2.46 – 2.40 (m, 1H), 2.36 – 2.29 (m, 2H), 2.30 – 2.24 (m, 1H), 2.20 – 2.09 (m, 2H), 2.04 – 2.01 (m, 1H), 1.88 – 1.71 (m, 4H), 1.71 – 1.68 (m, 1H), 1.65 – 1.60 (m, 1H), 1.51 – 1.38 (m, 6H), 1.32 – 1.24 (m, 7H), 1.19 – 1.10 (m, 2H), 1.07 (s, 3H), 1.00 (d, *J* = 6.7 Hz, 3H), 1.01 – 0.92 (m, 7H), 0.68 (d, *J* = 4.3 Hz, 3H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 174.7, 174.3, 164.7, 133.5, 131.5, 131.1, 128.1, 127.0, 123.3, 57.1, 56.7, 55.9, 49.6, 49.4, 42.7, 40.3, 38.0, 37.0, 35.5, 35.3, 33.9, 33.5, 31.7, 30.8, 29.8, 28.2, 27.3, 26.5, 24.2, 22.3, 22.2, 21.8, 19.1, 18.4, 17.8, 12.1.

HRMS (ESI-TOF, m/z): calcd for $C_{41}H_{54}N_2NaO_5^+$ $[M+Na]^+$ 677.3925; found 677.3950.

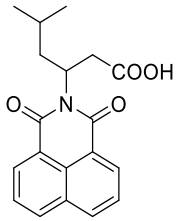


((*R*)-4-((3*S*,5*S*,8*R*,9*S*,10*S*,13*R*,14*S*,17*R*)-3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-10,13-dimethyl-7-oxohexadecahydro-1*H*-cyclopenta[*a*]phenanthren-17-yl) pentanoyl) alanine (1cc)

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.57 (d, *J* = 7.3 Hz, 2H), 8.20 (d, *J* = 8.3 Hz, 2H), 7.75 (t, *J* = 7.8 Hz, 2H), 5.24 – 5.19 (m, *J* = 12.1, 5.9 Hz, 1H), 4.56 (s, 1H), 2.69 – 2.58 (m, 2H), 2.57 – 2.42 (m, 3H), 2.32 (t, *J* = 11.6 Hz, 2H), 2.25 – 2.13 (m, 2H), 2.04 (d, *J* = 12.8 Hz, 1H), 1.94 (s, 1H), 1.85 (d, *J* = 13.7 Hz, 2H), 1.72 – 1.53 (m, 5H), 1.47 (d, *J* = 8.8 Hz, 5H), 1.41 – 1.32 (m, 4H), 1.29 – 1.20 (m, 2H), 1.15 – 1.10 (m, 3H), 0.98 (d, *J* = 6.4 Hz, 3H), 0.71 (s, 3H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 214.8, 174.5, 164.6, 133.6, 131.4, 131.1, 128.1, 127.0, 123.1, 54.7, 49.7, 49.1, 48.5, 47.5, 42.8, 42.6, 39.3, 38.9, 36.5, 35.5, 34.2, 33.3, 31.7, 29.5, 28.4, 25.6, 23.4, 22.3, 21.7, 18.6, 12.1.

HRMS (ESI-TOF, m/z): calcd for $C_{39}H_{48}N_2NaO_6^+$ [M+Na]$^+$ 663.3405; found 663.3436.

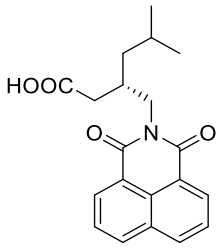


3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-5-methylhexanoic acid (3a)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (s, 2H), 8.22 (d, *J* = 6.0 Hz, 2H), 7.76 (t, *J* = 7.7 Hz, 2H), 5.74 – 5.69 (p, *J* = 6.7 Hz, 1H), 3.33 (dd, *J* = 16.5, 8.4 Hz, 1H), 2.97 (dd, *J* = 16.5, 6.3 Hz, 1H), 2.36 – 2.15 (m, 1H), 1.70 – 1.65 (m, 1H), 1.53 – 1.48 (m, 1H), 0.98 (d, *J* = 6.7 Hz, 3H), 0.91 (d, *J* = 6.7 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 176.8, 164.8, 133.9, 131.6, 128.4, 127.1, 48.0, 41.4, 37.3, 25.5, 23.2, 22.5.

HRMS (ESI-TOF, m/z): calcd for $C_{19}H_{19}NaNO_4^+$ [M+Na]$^+$ 348.1206; found 348.1216.

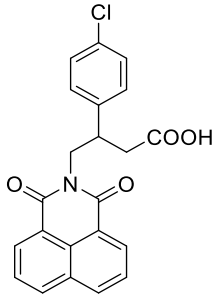


(*S*)-3-((1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) methyl)-5-methylhexanoic acid (3d)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (d, *J* = 7.1 Hz, 2H), 8.18 (d, *J* = 8.1 Hz, 2H), 7.73 (t, *J* = 7.7 Hz, 2H), 4.22 – 4.08 (m, 2H), 2.58 – 2.48 (m, 1H), 2.31 (dd, *J* = 15.8, 6.5 Hz, 1H), 2.24 (dd, *J* = 15.8, 6.3 Hz, 1H), 1.83 – 1.79 (m, 1H), 1.33 – 1.27 (m, 2H), 0.99 (d, *J* = 6.5 Hz, 3H), 0.91 (d, *J* = 6.5 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 176.7, 164.8, 134.1, 131.6, 131.5, 128.2, 127.0, 122.4, 44.0, 42.1, 37.4, 32.0, 25.4, 22.9, 22.5.

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{21}NaNO_4^+$ [M+Na]$^+$ 348.1206; found 348.1216.

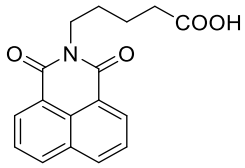


3-(4-chlorophenyl)-4-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) butanoic acid (3e)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.57 (d, *J* = 7.2 Hz, 2H), 8.20 (d, *J* = 8.1 Hz, 2H), 7.78 – 7.71 (m, 2H), 7.28 (d, *J* = 8.5 Hz, 2H), 7.24 (d, *J* = 8.6 Hz, 2H), 4.43 (dd, *J* = 12.9, 8.2 Hz, 1H), 4.30 (dd, *J* = 13.9, 7.0 Hz, 1H), 3.79 (p, *J* = 7.7 Hz, 1H), 2.74 (d, *J* = 7.3 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 175.5, 164.4, 139.4, 134.2, 132.9, 131.6, 131.5, 129.2, 129.1, 128.8, 128.2, 128.1, 127.0, 122.3, 45.0, 39.6, 37.7.

HRMS (ESI-TOF, m/z): calcd for $C_{22}H_{17}ClNO_4^+$ $[M+H]^+$ 394.0841; found 394.0864.

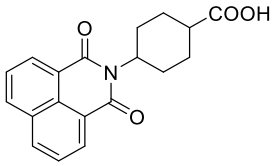


5-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) pentanoic acid (3f)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (d, *J* = 7.4 Hz, 2H), 8.21 (d, *J* = 8.2 Hz, 2H), 7.76 (t, *J* = 7.3 Hz, 2H), 4.22 (t, *J* = 7.1 Hz, 2H), 2.45 (t, *J* = 7.6 Hz, 2H), 1.80 (dq, *J* = 22.6, 7.6 Hz, 4H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 178.2, 164.4, 134.1, 131.7, 131.4, 128.3, 127.1, 122.8, 39.9, 33.6, 27.7, 22.3.

HRMS (ESI-TOF, m/z): calcd for $C_{17}H_{15}NaNO_4^+$ $[M+Na]^+$ 320.0893; found 320.0899.

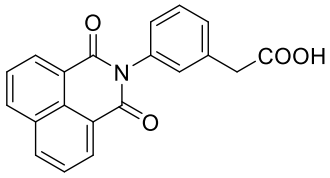


4-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) cyclohexane-1-carboxylic acid (3g)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.48 – 8.40 (m, 4H), 7.85 (t, *J* = 7.8 Hz, 2H), 4.90 (m, 1H), 2.67 – 2.51 (m, 3H), 2.21 (d, *J* = 14.1 Hz, 2H), 1.59 – 1.53 (m, 4H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 175.4, 163.7, 134.0, 131.2, 130.7, 127.4, 127.3, 122.5, 52.5, 37.6, 27.1, 25.3.

HRMS (ESI-TOF, m/z): calcd for $C_{19}H_{18}NO_4^+$ $[M+H]^+$ 324.1230; found 324.1272.

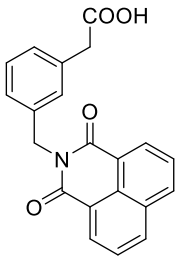


2-(3-(1,3-dioxo-1H-benzo[*de*]isoquinolin-2(3*H*)-yl) phenyl) acetic acid (3h)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.50 (t, *J* = 7.3 Hz, 4H), 7.90 (t, *J* = 7.7 Hz, 2H), 7.47 (t, *J* = 7.9 Hz, 1H), 7.37 (d, *J* = 7.7 Hz, 1H), 7.28 (s, 2H), 3.64 (s, 2H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 172.4, 163.7, 135.9, 135.8, 134.5, 131.5, 130.7, 129.8, 129.4, 128.7, 127.9, 127.4, 127.3, 122.6, 40.4.

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{14}NO_4^+$ $[M+H]^+$ 332.0917; found 332.0915.

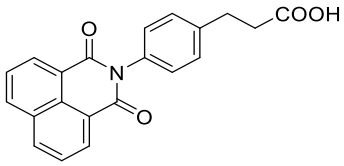


2-(3-((1,3-dioxo-1H-benzo[de]isoquinolin-2(3H)-yl) methyl) phenyl) acetic acid (3i)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.54 – 8.46 (m, 4H), 7.91 – 7.88 (m, 2H), 7.25 (d, *J* = 9.0 Hz, 1H), 7.18 (t, *J* = 6.7 Hz, 1H), 7.13 (t, *J* = 6.8 Hz, 1H), 7.07 (d, *J* = 7.8 Hz, 1H), 5.24 (s, 2H), 3.88 (s, 2H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 172.5, 163.6, 136.0, 134.6, 133.1, 131.4, 131.0, 130.7, 127.6, 127.3, 127.1, 126.8, 126.1, 122.0, 40.5, 38.5.

HRMS (ESI-TOF, m/z): calcd for $C_{21}H_{15}NNaO_4^+$ $[M+Na]^+$ 368.0893; found 368.0922.

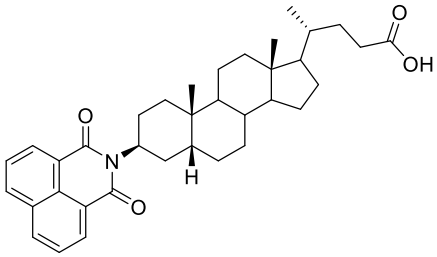


3-(4-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) phenyl) propanoic acid (3j)

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.50 (dd, *J* = 7.6, 5.3 Hz, 4H), 7.90 (t, *J* = 7.7 Hz, 2H), 7.37 (d, *J* = 8.2 Hz, 2H), 7.28 (d, *J* = 8.2 Hz, 2H), 2.92 (t, *J* = 7.6 Hz, 2H), 2.63 (t, *J* = 7.7 Hz, 2H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 173.8, 163.8, 140.9, 134.4, 133.9, 131.5, 130.8, 128.9, 128.7, 127.9, 127.3, 122.6, 35.1, 30.0.

HRMS (ESI-TOF, m/z): calcd for $C_{21}H_{16}NO_4^+$ $[M+H]^+$ 346.1074; found 346.1093.

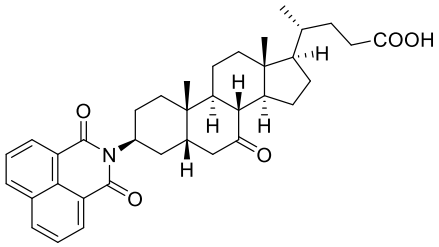


(4*R*)-4-((3*S*,5*R*,10*S*,13*R*)-3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-10,13-dimethylhexadecahydro-1*H*-cyclopenta[*a*]phenanthren-17-yl) pentanoic acid (3k)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.58 (d, *J* = 8.4 Hz, 2H), 8.19 (d, *J* = 9.4 Hz, 2H), 7.74 (t, *J* = 7.7 Hz, 2H), 5.27 – 5.21 (m, 1H), 2.46 – 2.38 (m, 2H), 2.32 – 2.24 (m, 2H), 2.16 – 2.10 (m, 1H), 2.00 – 1.97 (m, 1H), 1.89 – 1.70 (m, 5H), 1.67 – 1.64 (m, 1H), 1.61 – 1.56 (m, 1H), 1.48 – 1.40 (m, 5H), 1.39 – 1.27 (m, 5H), 1.20 – 1.11 (m, 2H), 1.08 (s, 3H), 1.06 – 0.99 (m, 2H), 0.97 – 0.92 (m, 4H), 0.69 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 178.0, 164.7, 133.6, 131.5, 131.1, 128.2, 127.0, 123.3, 56.7, 55.9, 49.6, 49.4, 42.7, 40.3, 38.0, 37.0, 35.4, 33.9, 30.8, 30.6, 29.8, 28.2, 27.3, 26.5, 24.2, 22.3, 22.2, 21.8, 18.3, 12.1.

HRMS (ESI-TOF, m/z): calcd for $C_{36}H_{45}NaNO_4^+$ $[M+Na]^+$ 578.3241; found 578.3226.

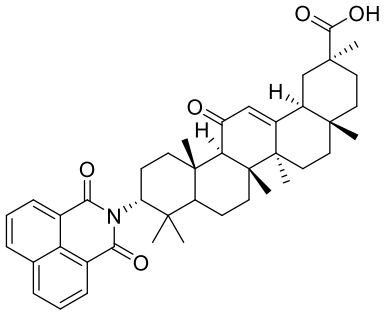


(*R*)-4-((3*S*,5*S*,8*R*,9*S*,10*S*,13*R*,14*S*,17*R*)-3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-10,13-dimethyl-7-oxohexadecahydro-1*H*-cyclopenta[*a*]phenanthren-17-yl) pentanoic acid (3i)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.57 (d, *J* = 7.4 Hz, 2H), 8.20 (d, *J* = 8.2 Hz, 2H), 7.75 (t, *J* = 7.7 Hz, 2H), 5.24 – 5.17 (m, 1H), 2.67 – 2.56 (m, 2H), 2.55 – 2.37 (m, 4H), 2.33 – 2.19 (m, 3H), 2.04 – 2.00 (m, 1H), 1.94 – 1.90 (m, 1H), 1.85 – 1.81 (m, 2H), 1.71 – 1.52 (m, 4H), 1.51 – 1.42 (m, 2H), 1.41 – 1.32 (m, 4H), 1.29 (s, 4H), 1.14 – 1.06 (m, 3H), 0.95 (d, *J* = 6.5 Hz, 3H), 0.69 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 214.8, 179.2, 164.7, 133.7, 131.5, 131.2, 128.1, 127.0, 123.1, 54.7, 49.6, 49.0, 48.5, 47.6, 42.9, 42.7, 39.3, 38.9, 36.4, 35.3, 34.2, 31.0, 30.8, 29.5, 28.3, 25.6, 23.4, 22.3, 21.7, 18.4, 12.1.

HRMS (ESI-TOF, m/z): calcd for $C_{36}H_{44}NO_5^+$ $[M+H]^+$ 570.3214; found 570.3243.



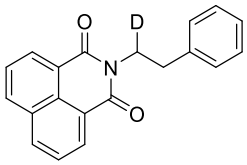
(2*S*,4a*S*,6a*S*,6b*R*,10*R*,12a*S*,12b*R*,14b*S*)-10-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-2,4a,6a,6b,9,9,12a-heptamethyl-13-oxo-1,2,3,4,4a,5,6,6a,6b,7,8,8a,9,10,11,12,12a,12b,13,14b-icosahydropicene-2-carboxylic acid (3m)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (d, *J* = 7.3 Hz, 1H), 8.53 (d, *J* = 7.3 Hz, 1H), 8.21 – 8.16 (m, 2H), 7.77 – 7.73 (m, 2H), 5.75 (s, 1H), 5.51 (dd, *J* = 11.3, 2.8 Hz, 1H), 2.84 – 2.77 (m, 1H), 2.68 (s, 1H), 2.36 – 2.30 (m, *Z*1H), 2.22 (dd, *J* = 13.3, 4.2 Hz, 1H), 2.08 – 1.94 (m, 4H), 1.89 – 1.84 (m, 1H), 1.81 – 1.72 (m, 4H), 1.67 (t, *J* = 13.5 Hz, 2H), 1.56 (d, *J* = 5.8 Hz, 2H), 1.46 (s, 3H), 1.45 (s, 3H), 1.43 (s, 2H), 1.25 (d, 4H), 1.23 – 1.21 (m, 1H), 1.16 (s, 3H), 1.00 (s, 6H), 0.86 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 199.9, 180.6, 169.5, 166.1, 165.4, 133.4, 133.3, 131.5, 131.4, 130.9, 128.6, 128.2, 127.0, 126.9, 123.8, 123.1, 63.2, 57.5, 50.7, 48.3, 45.6, 43.8, 43.4, 41.7, 41.1, 39.7, 37.8, 36.7, 32.2, 31.9, 31.0, 28.6, 28.5, 26.5, 26.1, 25.2, 24.7, 23.5, 21.6, 19.3, 18.4.

HRMS (ESI-TOF, m/z): calcd for $C_{42}H_{52}NO_5^+$ $[M+H]^+$ 650.3840; found 650.3864.

6.2 Characterization of products



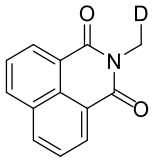
2-(2-phenylethyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2a)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2a** was obtained in 70% yield as a withe powder with 95% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.62 (d, *J* = 7.2 Hz, 2H), 8.22 (d, *J* = 8.2 Hz, 2H), 7.77 (t, *J* = 7.7 Hz, 2H), 7.38 (d, *J* = 7.5 Hz, 2H), 7.32 (t, *J* = 7.4 Hz, 2H), 7.23 (t, *J* = 7.3 Hz, 1H), 4.39 (t, *J* = 8.1 Hz, 1H), 3.03 (d, *J* = 8.2 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 166.8, 144.6, 136.3, 131.8, 131.4, 129.2, 128.6, 128.3, 127.1, 126.6, 122.8, 41.8 (t, *J* = 21.8 Hz, C-D), 30.4.

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{15}DNO_2^+$ $[M+H]^+$:303.1238, found 303.1279.



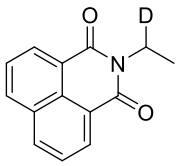
2-(methyl-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2d)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2d** was obtained in 71% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61 (d, *J* = 7.2 Hz, 2H), 8.22 (d, *J* = 8.1 Hz, 2H), 7.76 (t, *J* = 7.7 Hz, 2H), 3.55 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.5, 136.0, 131.6, 131.2, 128.1, 126.9, 122.6, 26.8(t, *J* = 21.5 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{13}H_9DNO_2^+$ $[M+H]^+$: 213.0769, found 213.0765.



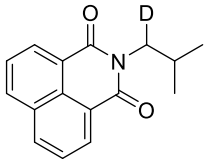
2-(ethyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2e)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2e** was obtained in 84% yield as a withe powder with 95% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61 (d, *J* = 8.4 Hz, 2H), 8.21 (d, *J* = 8.3 Hz, 2H), 7.75 (t, *J* = 7.7 Hz, 2H), 4.24 (q, *J* = 6.9 Hz, 1H), 1.33 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.2, 134.0, 131.8, 131.3, 128.3, 127.1, 123.0, 35.4 (t, *J* = 22.0 Hz, C-D), 13.4.

HRMS (ESI-TOF, m/z): calcd for $C_{14}H_{11}DNO_2^+$ $[M+H]^+$: 227.0925, found 227.0956.



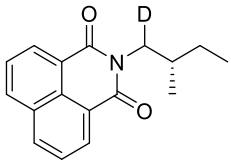
2-(2-methylpropyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2f)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2f** was obtained in 86% yield as a withe powder with 97% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (d, *J* = 7.3 Hz, 2H), 8.21 (d, *J* = 8.2 Hz, 2H), 7.75 (t, *J* = 7.7 Hz, 2H), 4.04 (d, *J* = 7.4 Hz, 1H), 2.28 – 2.22 (m, 1H), 0.99 (dd, *J* = 6.7, 1.3 Hz, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.7, 140.0, 131.7, 131.4, 128.4, 127.1, 122.9, 47.1(t, *J* = 21.2 Hz, C-D), 27.5, 20.4.

HRMS (ESI-TOF, m/z): calcd for $C_{16}H_{15}DNO_2^+$ $[M+H]^+$: 255.1238, found 255.1243.



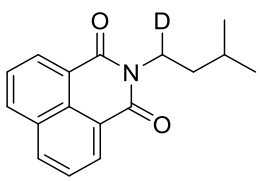
2-((2*S*)-2-methylbutyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2g)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2g** was obtained in 90% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61 (d, *J* = 9.5 Hz, 2H), 8.22 (d, *J* = 7.1 Hz, 2H), 7.76 (t, *J* = 7.8 Hz, 2H), 4.09 (d, *J* = 6.9 Hz, 1H), 2.04 (dt, *J* = 14.4, 6.9 Hz, 1H), 1.50 (dt, *J* = 12.9, 7.3 Hz, 1H), 1.36 – 1.22 (m, 1H), 1.03 – 0.91 (m, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.7, 134.0, 131.7, 131.4, 128.4, 127.1, 122.9, 45.9(t, *J* = 21.7 Hz, C-D), 33.8, 27.5, 17.1, 11.5.

HRMS (ESI-TOF, m/z): calcd for $C_{17}H_{17}DNO_2^+$ $[M+H]^+$: 269.1395, found 269.1413.



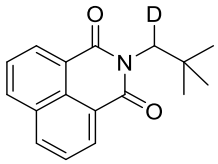
2-(3-methylbutyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2h)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2h** was obtained in 77% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (d, *J* = 7.2 Hz, 2H), 8.20 (d, *J* = 7.9 Hz, 2H), 7.75 (t, *J* = 7.7 Hz, 2H), 4.18 (t, *J* = 7.9 Hz, 1H), 1.77 – 1.68 (m, 1H), 1.61 (t, *J* = 7.6 Hz, 2H), 1.01 (d, *J* = 6.6 Hz, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.3, 134.0, 131.7, 131.3, 128.3, 127.1, 123.0, 39.0(t, *J* = 22.0 Hz, C-D), 37.0, 26.6, 22.7, 22.7.

HRMS (ESI-TOF, m/z): calcd for $C_{17}H_{17}DNO_2^+$ $[M+H]^+$: 269.1395, found 269.1410.



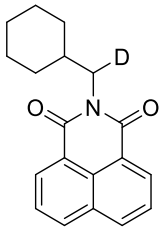
2-(2,2-dimethylpropyl-1-d)-1H-benzo[de]isoquinoline-1,3(2H)-dione (2i)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2i** was obtained in 90% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59(d, *J* = 7.6 Hz, 2H), 8.20(d, *J* = 7.6 Hz, 2H), 7.75(t, *J* = 7.6 Hz, 2H), 4.13(s, 1H), 1.02(s, 9H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 165.0, 133.8, 131.7, 131.4, 128.2, 127.1, 123.0, 49.4(t, *J* = 21.0 Hz, C-D), 34.2, 28.9.

HRMS (ESI-TOF, m/z): calcd for $C_{17}H_{17}DNO_2^+$ $[M+H]^+$: 269.1395, found 269.1408.



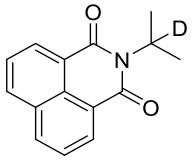
2-(cyclohexylmethyl-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2j)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2j** was obtained in 95% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (d, *J* = 7.2 Hz, 2H), 8.20 (d, *J* = 8.2 Hz, 2H), 7.75 (t, *J* = 7.7 Hz, 2H), 4.06 (dd, *J* = 12.3, 7.3 Hz, 1H), 1.94 – 1.87 (m, 1H), 1.73 (d, *J* = 12.5 Hz, 4H), 1.64 (s, 1H), 1.25 – 1.08 (m, 5H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.7, 133.9, 131.7, 131.4, 128.4, 127.1, 122.9, 46.0 (t, *J* = 21.5 Hz, C-D), 36.8, 31.1, 26.5, 26.1.

HRMS (ESI-TOF, m/z): calcd for $C_{19}H_{19}DNO_2^+$ $[M+H]^+$: 295.1551, found 295.1527.



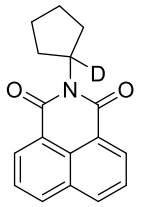
2-(propan-2-yl-2-d)-1H-benzo[de]isoquinoline-1,3(2H)-dione **(2k)**

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =5:1), compound **2k** was obtained in 47% yield as a withe powder with 86% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.58 (d, *J* = 7.2 Hz, 2H), 8.19(d, *J* = 8.2 Hz, 2H), 7.74(t, *J* = 7.8 Hz, 2H), 1.60(d, *J* = 8.0 Hz, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.7, 133.7, 131.6, 131.2, 128.4, 127.1, 123.4, 45.1(t, *J* = 21.3 Hz, C-D), 19.9, 19.8.

HRMS (ESI-TOF, m/z): calcd for $C_{15}H_{13}DNO_2^+$ $[M+H]^+$: 241.1082, found 241.1066.



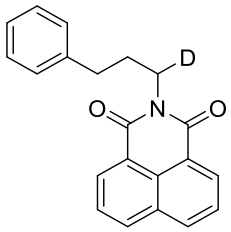
2-(cyclopentyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2l)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =5:1), compound **2l** was obtained in 68% yield as a withe powder with 88% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (d, *J* = 7.2 Hz, 2H), 8.19 (d, *J* = 8.2 Hz, 2H), 7.74 (t, *J* = 7.8 Hz, 2H), 2.25-2.20 (m, 2H), 2.11-2.05 (m, 2H), 1.96-1.92 (m, 2H), 1.71-1.66 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.7, 133.7, 131.6, 131.2, 128.3, 127.1, 123.4, 52.6(t, *J* = 21.8 Hz, C-D), 29.0, 28.9, 26.2.

HRMS (ESI-TOF, m/z): calcd for $C_{17}H_{15}DNO_2^+$ $[M+H]^+$: 267.1238, found 267.1196.



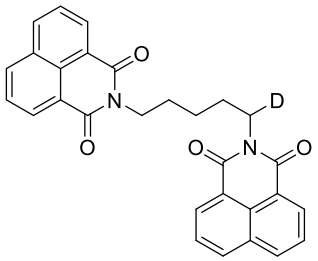
2-(3-phenylpropyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione **(2m)**

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2m** was obtained in 90% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (d, *J* = 8.4 Hz, 2H), 8.20 (d, *J* = 9.4 Hz, 2H), 7.80 – 7.67 (m, 2H), 7.33 – 7.21 (m, 4H), 7.16 – 7.07 (m, 1H), 4.23 (t, *J* = 7.6 Hz, 1H), 2.83 – 2.73 (m, 2H), 2.09 (q, *J* = 7.7 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.3, 141.6, 134.0, 131.7, 131.3, 128.4, 128.3, 127.1, 125.9, 122.8, 40.2(t, *J* = 21.7 Hz, C-D), 33.6, 29.4.

HRMS (ESI-TOF, m/z): calcd for $C_{21}H_{17}DNO_2^+$ $[M+H]^+$: 317.1395, found 317.1397.



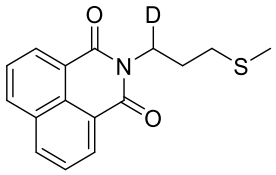
2,2'-(pentane-1,5-diyl-1-*d*) bis(1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione) (2n)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =100:1), compound **2n** was obtained in 70% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.54 (d, *J* = 7.3 Hz, 4H), 8.19 (d, *J* = 8.2 Hz, 4H), 7.72 (t, *J* = 7.7 Hz, 4H), 4.24 – 4.17 (m, 3H), 1.84 (p, *J* = 7.4 Hz, 4H), 1.59 – 1.53 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.3, 133.9, 131.7, 131.3, 128.3, 127.0, 122.9, 40.3, 40.1(t, *J* = 22.1 Hz, C-D), 28.0, 27.9, 24.7.

HRMS (ESI-TOF, m/z): calcd for $C_{29}H_{21}DNNaO_4^+$ $[M+Na]^+$: 486.1535, found 486.1530.



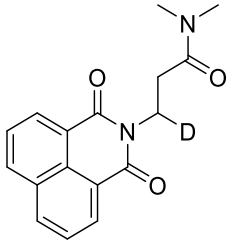
2-(3-(methylthio) propyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2o)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **2o** was obtained in 68% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (d, *J* = 7.2 Hz, 2H), 8.21 (d, *J* = 8.1 Hz, 2H), 7.76 (t, *J* = 7.8 Hz, 2H), 4.28 (t, *J* = 7.4 Hz, 1H), 2.63 (t, *J* = 7.5 Hz, 2H), 2.13 (s, 3H), 2.05 (q, *J* = 7.4 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.4, 134.1, 131.8, 131.4, 128.4, 127.1, 122.8, 39.5(t, *J* = 21.5 Hz, C-D), 31.8, 27.5, 15.5.

HRMS (ESI-TOF, m/z): calcd for $C_{16}H_{15}DNO_2S^+$ $[M+H]^+$: 287.0959, found 287.0964.



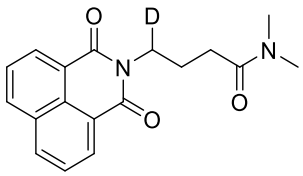
3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-*N*, *N*-dimethylpropanamide-3-*d* (2p)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =50:1), compound **2p** was obtained in 69% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61 (d, *J* = 7.3 Hz, 2H), 8.21 (d, *J* = 8.1 Hz, 2H), 7.75 (t, *J* = 7.7 Hz, 2H), 4.49 (t, *J* = 8.1 Hz, 1H), 3.02 (s, 3H), 2.96 (s, 3H), 2.78 (d, *J* = 8.1 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 170.7, 164.3, 134.1, 131.8, 131.4, 128.3, 127.1, 122.7, 37.3, 36.8(t, *J* = 22.0 Hz, C-D), 35.4, 31.7.

HRMS (ESI-TOF, m/z): calcd for $C_{17}H_{16}DN_2O_3^+$ $[M+H]^+$: 298.1296, found 298.1314.



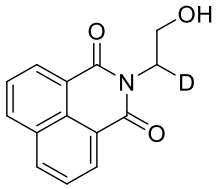
4-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-*N*, *N*-dimethylbutanamide-4-*d* (2q)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =50:1), compound **2q** was obtained in 65% yield as a withe powder with 97% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (d, *J* = 7.3 Hz, 2H), 8.20 (d, *J* = 8.2 Hz, 2H), 7.74 (t, *J* = 7.7 Hz, 2H), 4.24 (t, *J* = 7.0 Hz, 1H), 2.99 (s, 3H), 2.88 (s, 3H), 2.44 (t, *J* = 7.6 Hz, 2H), 2.11 (q, *J* = 7.4 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 172.3, 164.4, 134.0, 131.7, 131.3, 128.3, 127.1, 122.8, 39.8(t, *J* = 21.8 Hz, C-D), 37.4, 35.6, 31.0, 23.8.

HRMS (ESI-TOF, m/z): calcd for $C_{18}H_{18}DN_2O_3^+$ $[M+H]^+$: 312.1453, found 312.1458.



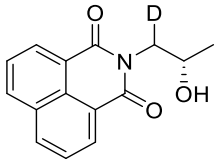
2-(2-hydroxyethyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2r)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =20:1), compound **2r** was obtained in 78% yield as a withe powder with 96% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.62 (d, *J* = 7.3 Hz, 2H), 8.23 (d, *J* = 8.2 Hz, 2H), 7.77 (t, *J* = 7.7 Hz, 2H), 4.44 (d, *J* = 5.4 Hz, 1H), 3.99 (d, *J* = 5.3 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 165.3, 134.4, 131.8, 131.7, 128.4, 127.2, 122.6, 62.0, 42.7(t, *J* = 21.5 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{14}H_{11}DNO_3^+$ $[M+H]^+$: 243.0874, found 243.0880.



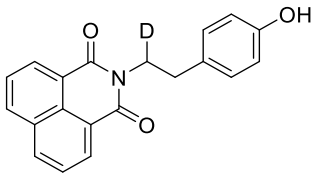
2-((2S)-2-hydroxypropyl-1-d)-1H-benzo[de]isoquinoline-1,3(2H)-dione (2s)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =30:1), compound **2s** was obtained in 77% yield as a withe powder with 97% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, DMSO-*d*$_6$) δ 8.49(d, *J* = 7.2 Hz, 2H), 8.45, (d, *J* = 8.2 Hz, 2H), 7.86 (t, *J* = 7.7 Hz, 2H), 4.75 (d, *J* = 5.0 Hz, 1H), 4.03 (q, *J* = 6.0 Hz, 1H), 3.86 (d, *J* = 5.3 Hz, 1H), 1.09 (d, *J* = 6.1 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 165.3, 134.3, 131.6, 131.6, 128.3, 127.0, 122.4, 67.6, 47.3(t, *J* = 21.2 Hz, C-D), 21.6.

HRMS (ESI-TOF, m/z): calcd for $C_{15}H_{13}DNO_3^+$ $[M+H]^+$: 257.1031, found 257.1039.



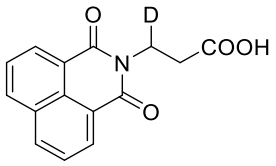
2-(2-(4-hydroxyphenyl) ethyl-1-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (2t)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =100:1), compound **2t** was obtained in 81% yield as a withe powder with 97% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, DMSO-*d*$_6$) δ 8.61 (d, *J* = 7.3 Hz, 2H), 8.22 (d, *J* = 8.3 Hz, 2H), 7.79 – 7.75 (m, 2H), 7.23 (d, *J* = 8.3 Hz, 2H), 6.78 (d, *J* = 8.4 Hz, 2H), 4.35 (t, *J* = 8.1 Hz, 1H), 2.96 (d, *J* = 8.2 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.8, 154.4, 134.2, 131.8, 131.4, 131.1, 130.3, 128.3, 127.1, 122.8, 115.5, 41.9(t, *J* = 21.6 Hz, C-D), 33.5.

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{15}DNO_3^+$ $[M+H]^+$: 319.1187, found 319.1190.



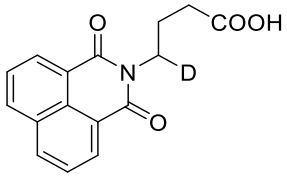
3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) propanoic-3-*d* acid (2u)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =10:1), compound **2u** was obtained in 47% yield as a withe powder with 94% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.63 (d, *J* = 7.2 Hz, 2H), 8.24 (d, *J* = 8.3 Hz, 2H), 7.80 – 7.74 (m, 2H), 4.51 (t, *J* = 7.4 Hz, 1H), 2.85 (d, *J* = 7.4 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 174.41, 164.26, 134.36, 131.80, 131.62, 128.38, 127.15, 122.58, 35.8(t, *J* = 22.2 Hz, C-D), 32.22.

HRMS (ESI-TOF, m/z): calcd for $C_{15}H_{11}DNO_4^+$ $[M+H]^+$: 271.0824, found 271.0884.



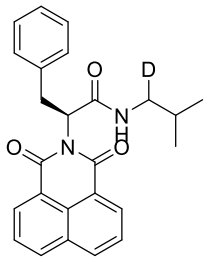
4-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) butanoic-4-*d* acid (2v)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =10:1), compound **2v** was obtained in 51% yield as a withe powder with 93% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61(d, *J* = 7.3 Hz, 2H), 8.22(d, *J* = 8.2 Hz, 2H), 7.76(t, *J* = 7.8 Hz, 2H), 4.26(t, *J* = 7.1 Hz, 1H), 2.47(t, *J* = 7.5 Hz, 2H), 2.10(q, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 176.4, 164.5, 134.2, 131.8, 131.6, 128.4, 127.1, 122.7, 39.3(t, *J* = 21.3 Hz, C-D), 31.4, 29.9, 23.3.

HRMS (ESI-TOF, m/z): calcd for $C_{16}H_{13}DNO_4^+$ $[M+H]^+$: 285.0980, found 285.0983.



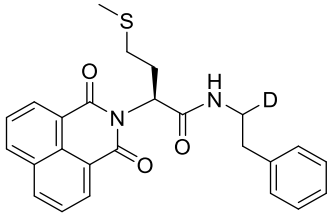
(2*S*)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-*N*-(2-methylpropyl-1-*d*)-3-phenylpropanamide (2w)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =200:1), compound **2w** was obtained in 79% yield as a withe powder with 97% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.54 (d, *J* = 7.2 Hz, 2H), 8.20 (d, *J* = 8.2 Hz, 2H), 7.73 (t, *J* = 7.7 Hz, 2H), 7.26 (s, 2H), 7.16 (t, *J* = 7.5 Hz, 2H), 7.09 (t, *J* = 7.3 Hz, 1H), 6.04 (t, *J* = 7.8 Hz, 1H), 5.80 (d, *J* = 6.1 Hz, 1H), 3.73 (dd, *J* = 14.2, 7.0 Hz, 1H), 3.52 (dd, *J* = 14.2, 8.6 Hz, 1H), 3.14 (t, *J* = 6.6 Hz, 1H), 1.72 (h, *J* = 6.7 Hz, 1H), 0.82 (dd, *J* = 6.8, 3.4 Hz, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 169.1, 164.6, 137.7, 134.3, 131.7, 131.7, 129.2, 128.8, 128.3, 127.1, 126.9, 122.4, 56.0, 47.0(t, *J* = 21.0 Hz, C-D), 35.1, 28.4, 20.1.

HRMS (ESI-TOF, m/z): calcd for $C_{25}H_{24}DN_2O_3^+$ [M+H]$^+$: 402.1922, found 402.1969.



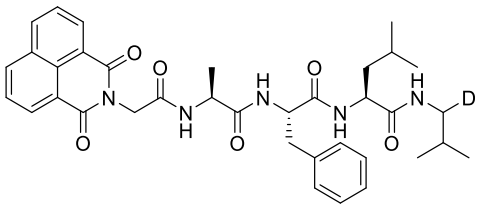
(2*S*)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-4-(methylthio)-*N*-(2-phenylethyl-1-d) butanamide (2x)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: DCM/MeOH =200:1), compound **2x** was obtained in 67% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (d, *J* = 6.2 Hz, 2H), 8.27 (d, *J* = 8.2 Hz, 2H), 7.79 (t, *J* = 7.7 Hz, 2H), 7.07 (d, *J* = 7.3 Hz, 2H), 6.95 (dt, *J* = 13.4, 7.1 Hz, 3H), 5.77 (dd, *J* = 8.6, 5.4 Hz, 1H), 5.72 (d, *J* = 6.1 Hz, 1H), 3.62 (q, *J* = 6.5 Hz, 1H), 2.77 (dd, *J* = 6.8, 3.7 Hz, 2H), 2.66 (dq, *J* = 13.6, 6.6 Hz, 1H), 2.44 (dq, *J* = 14.5, 7.8 Hz, 1H), 2.05 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 169.1, 164.3, 138.9, 134.5, 132.0, 131.7, 128.9, 128.5, 128.5, 127.3, 126.4, 122.4, 54.0, 40.7 (t, *J* = 21.0 Hz, C-D), 35.6, 31.5, 28.1, 15.5.

HRMS (ESI-TOF, m/z): calcd for $C_{25}H_{24}DN_2O_3^+$ [M+H]$^+$: 434.1643, found 434.1656.



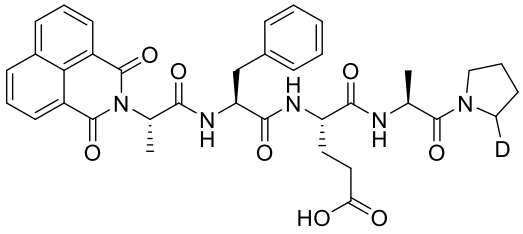
(2*S*)-2-((*S*)-2-((*S*)-2-(2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) acetamido) propanamido)-3-phenylpropanamido)-4-methyl-*N*-(2-methylpropyl-1-*d*) pentanamide (2y)

Following GP1 with reaction time of 3 d. After purified by reverse-phase HPLC (45% MeCN/H_2O containing 0.1 Formic Acid, Rt = 27.0 min), compound **2y** was obtained in 61% yield as a withe powder with 97% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, DMSO-d_6) δ 8.69 (d, *J* = 6.7 Hz, 1H), 8.52 (d, *J* = 7.1 Hz, 4H), 7.92 (t, *J* = 7.7 Hz, 3H), 7.71 (d, *J* = 8.2 Hz, 1H), 7.49 (d, *J* = 5.8 Hz, 1H), 7.28 (q, *J* = 8.0 Hz, 4H), 7.20 (t, *J* = 6.9 Hz, 1H), 4.79 (d, *J* = 15.9 Hz, 1H), 4.69 (d, *J* = 15.9 Hz, 1H), 4.44 (ddd, *J* = 9.5, 7.8, 4.9 Hz, 1H), 4.23 (p, *J* = 7.0 Hz, 1H), 4.14 (q, *J* = 8.2 Hz, 1H), 3.11 (dd, *J* = 14.0, 4.8 Hz, 1H), 2.92 (dd, *J* = 14.0, 9.6 Hz, 1H), 2.83 – 2.77 (m, 1H), 1.63 (h, *J* = 6.7 Hz, 1H), 1.38 – 1.31 (m, 3H), 1.18 (d, *J* = 7.1 Hz, 3H), 0.79 (dd, *J* = 6.7, 3.0 Hz, 6H), 0.59 (dd, *J* = 18.9, 5.8 Hz, 6H).

^{13}C NMR (151 MHz, DMSO-d_6) δ 172.8, 171.9, 170.9, 167.8, 163.9, 138.2, 135.2, 131.9, 131.4, 129.6, 128.6, 128.0, 127.8, 126.8, 122.4, 54.8, 51.8, 49.3, 46.1 (t, *J* = 21.8 Hz, C-D), 42.9, 41.2, 37.2, 28.3, 24.5, 23.1, 21.7, 20.4, 20.4, 18.3.

HRMS (ESI-TOF, m/z): calcd for $C_{36}H_{43}DN_5O_6^+$ [M+H]$^+$: 643.3349, found 643.3376.



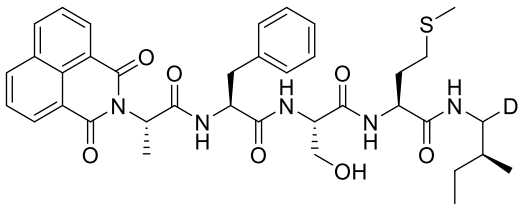
(4*S*)-4-((*S*)-2-((*S*)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) propanamido)-3-phenylpropanamido)-5-oxo-5-(((2*S*)-1-oxo-1-(pyrrolidin-1-yl-2-*d*) propan-2-yl) amino) pentanoic acid (2z)

Following GP1 with reaction time of 3 d. After purified by reverse-phase HPLC (38% MeCN/H_2O containing 0.1 Formic Acid, Rt = 16.2 min), compound **2z** was obtained in 47% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, MeOD) δ 8.55 (d, *J* = 6.2 Hz, 2H), 8.41 (d, *J* = 7.2 Hz, 2H), 7.88 – 7.84 (m, 2H), 7.18 (d, *J* = 6.7 Hz, 2H), 7.11 (dt, *J* = 23.2, 7.1 Hz, 3H), 5.60 (q, *J* = 7.0 Hz, 1H), 4.54 (dd, *J* = 10.1, 4.5 Hz, 1H), 4.46 – 4.38 (m, 2H), 3.63 (dq, *J* = 13.0, 6.6 Hz, 1H), 3.46 – 3.35 (m, 2H), 3.26 (dd, *J* = 14.1, 4.5 Hz, 1H), 3.06 – 3.01 (m, 1H), 2.51 (s, 2H), 2.27 (q, *J* = 11.3, 9.6 Hz, 1H), 2.15 (ddt, *J* = 13.3, 8.8, 3.8 Hz, 1H), 1.97 (qd, *J* = 6.6, 3.9 Hz, 2H), 1.91 – 1.83 (m, 2H), 1.63 (d, *J* = 7.0 Hz, 3H), 1.14 (d, *J* = 7.0 Hz, 3H).

^{13}C NMR (151 MHz, MeOD) δ 172.3, 171.8, 171.7, 171.1, 163.9, 137.4, 134.5, 131.8, 131.4, 128.6, 128.1, 128.0, 126.9, 126.3, 122.1, 55.5, 52.9, 50.1, 48.2, 46.1, 45.9, 45.6 (t, *J* = 20.8 Hz, C-D), 35.7, 27.0, 25.6, 25.5, 23.6, 23.5, 15.5, 12.9.

HRMS (ESI-TOF, m/z): calcd for $C_{36}H_{39}DN_5O_8^+$ $[M+H]^+$: 671.2934, found 671.2918.



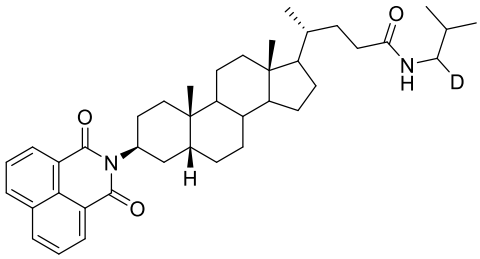
(2*S*)-2-((*S*)-2-((*S*)-2-((*S*)-2-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl) propanamido)-3-phenylpropanamido)-3-hydroxypropanamido)-*N*-((2*S*)-2-methylbutyl-1-*d*)-4-(methylthio) butanamide (2aa)

Following GP1 with reaction time of 3 d. After purified by reverse-phase HPLC (45% MeCN/H_2O containing 0.1 Formic Acid, Rt = 29.1 min), compound **2aa** was obtained in 51% yield as a withe powder with 95% D-incorporation (determined by ^{1}H NMR).

1H NMR (600 MHz, DMSO-*d*$_6$) δ 8.49 (d, *J* = 8.3 Hz, 2H), 8.45 (d, *J* = 7.3 Hz, 2H), 8.22 (d, *J* = 7.3 Hz, 1H), 8.06 (d, *J* = 7.1 Hz, 1H), 8.00 (d, *J* = 7.8 Hz, 1H), 7.94 – 7.86 (m, 2H), 7.71 (d, *J* = 5.9 Hz, 1H), 7.12 – 7.04 (m, 3H), 7.03 – 6.96 (m, 2H), 5.43 (q, *J* = 6.9 Hz, 1H), 5.24 (s, 1H), 4.41 (ddd, *J* = 11.0, 7.5, 3.8 Hz, 1H), 4.33 – 4.28 (m, 2H), 3.71 (dt, *J* = 10.7, 5.5 Hz, 1H), 3.62 – 3.57 (m, 1H), 2.94 – 2.85 (m, 2H), 2.79 (dd, *J* = 14.1, 10.2 Hz, 1H), 2.45 – 2.35 (m, 2H), 1.99 (s, 4H), 1.78 (dq, *J* = 13.7, 4.5 Hz, 1H), 1.46 (d, *J* = 6.9 Hz, 4H), 1.35 – 1.28 (m, 1H), 1.07 – 1.02 (m, 1H), 0.85 – 0.77 (m, 6H).

13C NMR (151 MHz, DMSO-*d*$_6$) δ 171.8, 170.7, 170.1, 169.6, 163.1, 138.2, 134.3, 131.2, 130.8, 128.9, 127.8, 127.6, 127.1, 125.9, 122.4, 61.5, 55.2, 54.8, 52.1, 49.3, 43.9 (t, *J* = 21.2 Hz, C-D), 36.1, 34.2, 31.5, 29.6, 26.3, 16.9, 14.6, 14.1, 11.1.

HRMS (ESI-TOF, m/z): calcd for $C_{37}H_{44}DN_5NaO_7S^+$ [M+Na]$^+$: 727.2995, found 727.3018.



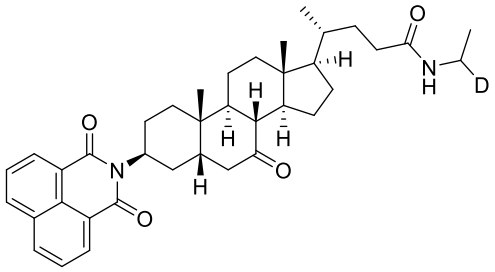
(4*R*)-4-((3*S*,5*R*,10*S*,13*R*)-3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-10,13-dimethylhexadecahydro-1*H*-cyclopenta[*a*]phenanthren-17-yl)-*N*-(2-methylpropyl-1-*d*) pentanamide (2bb)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =2:1), compound **2bb** was obtained in 53% yield as a withe powder with 93% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61 (d, *J* = 8.4 Hz, 2H), 8.21 (dd, *J* = 8.3, 1.1 Hz, 2H), 7.80 – 7.72 (m, 2H), 5.44 (s, 1H), 5.29 – 5.24 (m, 1H), 3.09 (dd, *J* = 12.1, 6.2 Hz, 1H), 2.46 (td, *J* = 12.1, 9.4 Hz, 1H), 2.36 – 2.31 (m, 1H), 2.27 (m, 1H), 2.18 – 2.08 (m, 2H), 2.03 – 1.99 (m, 1H), 1.90 – 1.74 (m, 5H), 1.70 – 1.67 (m, 1H), 1.51 – 1.41 (m, 6H), 1.38 – 1.27 (m, 7H), 1.20 – 1.13 (m, 2H), 1.10 (s, 3H), 1.06 – 1.02 (m, 1H), 0.97 (d, *J* = 6.5 Hz, 4H), 0.94 (d, *J* = 6.7 Hz, 6H), 0.70 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 173.6, 164.6, 133.5, 131.5, 131.1, 128.1, 126.9, 123.3, 56.7, 56.0, 49.6, 49.4, 46.7 (t, *J* = 21.5 Hz, C-D), 42.7, 40.3, 38.0, 37.0, 35.5, 35.3, 33.9, 32.0, 29.8, 28.5, 28.2, 27.3, 26.5, 24.2, 22.3, 22.2, 21.8, 20.1, 18.4, 12.1.

HRMS (ESI-TOF, m/z): calcd for $C_{40}H_{53}DN_2NaO_3^+$ [M+Na]$^+$: 634.4089, found 634.4100.



(4*R*)-4-((3*S*,5*S*,8*R*,9*S*,10*S*,13*R*,14*S*,17*R*)-3-(1,3-dioxo-1*H*-benzo[*de*]isoquinolin-2(3*H*)-yl)-10,13-dimethyl-7-oxohexadecahydro-1*H*-cyclopenta[*a*]phenanthren-17-yl)-*N*-(ethyl-1-d) pentanamide (2cc)

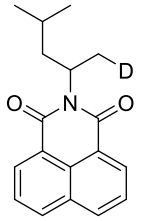
Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =1:1), compound **2cc** was obtained in 40% yield as a withe powder with 94% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (d, *J* = 7.3 Hz, 2H), 8.23 (d, *J* = 8.3 Hz, 2H), 7.78 (t, *J* = 7.8 Hz, 2H), 5.26 – 5.20 (m, 1H), 3.32 (m, 1H), 2.69 – 2.58 (m, 2H), 2.57 – 2.42 (m, 3H), 2.36 – 2.30 (m, 1H), 2.29 – 2.21 (m, 2H), 2.05 (d, *J* = 13.3 Hz, 1H), 1.99 – 1.94 (m, 1H), 1.86 (d, *J* = 13.8 Hz, 2H), 1.77 – 1.68 (m, 3H), 1.58 (s, 5H), 1.48 (d, *J* = 12.9 Hz, 3H), 1.41 – 1.32 (m, 4H), 1.28 (d, *J* = 10.9 Hz, 3H),

1.18 (s, 3H), 0.99 (s, 3H), 0.72 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 214.7, 173.4, 164.7, 133.7, 131.5, 131.2, 128.2, 127.0, 123.1, 54.7, 49.7, 49.0, 48.5, 47.6, 42.9, 42.7, 39.4, 39.0, 36.5, 35.4, 34.3, 34.2 (t, *J* = 21.0 Hz, C-D), 33.8, 31.9, 29.5, 28.4, 25.6, 23.4, 22.3, 21.7, 18.6, 12.1.

HRMS (ESI-TOF, m/z): calcd for $C_{38}H_{47}DN_2NaO_4^+$ $[M+Na]^+$: 620.3569, found 620.3603.



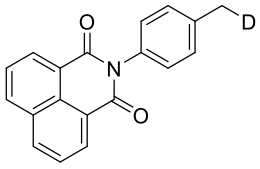
2-(4-methylpentan-2-yl-1-d)-1H-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4a)

Following GP2 with reaction time of 4 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4a** was obtained in 60% yield as a withe powder with 96% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, DMSO-*d*$_6$) δ 8.46 (dd, *J* = 27.6, 7.7 Hz, 4H), 7.92 – 7.83 (m, 2H), 5.32 – 5.18 (m, 1H), 2.18 – 2.12 (m, 1H), 1.59 (dt, *J* = 14.1, 7.3 Hz, 1H), 1.49 – 1.39 (m, 3H), 0.85 (dd, *J* = 17.9, 6.6 Hz, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.8, 133.7, 131.6, 131.2, 128.4, 127.1, 123.4, 48.0, 47.9, 42.9, 42.9, 25.9, 23.1, 22.7, 18.5(t, *J* = 19.6 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{16}H_{15}DNO_2^+$ $[M+H]^+$: 255.1238, found 255.1190.



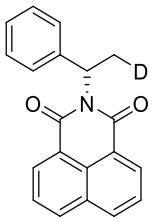
2-(4-(methyl-*d*) phenyl)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4b)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/DCM =1:2), compound **4b** was obtained in 98% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.66 (d, *J* = 7.2 Hz, 2H), 8.27 (d, *J* = 8.2 Hz, 2H), 7.79 (t, *J* = 7.7 Hz, 2H), 7.36 (d, *J* = 7.9 Hz, 2H), 7.21 (d, *J* = 7.9 Hz, 2H), 2.43 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.6, 138.7, 134.4, 132.9, 131.9, 131.8, 130.3, 128.7, 128.4, 127.2, 123.1, 21.2 (t, *J* = 19.8 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{19}H_{12}DNNaO_2^+$ $[M+Na]^+$: 311.0901, found 311.0941.



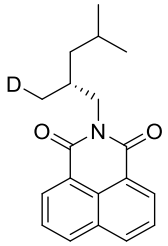
(*S*)-2-(1-phenylethyl-2-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4c)

Following GP2 and under the irradiation with 390nm LEDs with reaction time of 1 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4c** was obtained in 65% yield as a withe powder with 95% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.57 (d, *J* = 7.2 Hz, 2H), 8.20 (d, *J* = 8.2 Hz, 2H), 7.74 (t, *J* = 7.7 Hz, 2H), 7.51 (d, *J* = 7.8 Hz, 2H), 7.32 (t, *J* = 7.8 Hz, 2H), 7.23 (t, *J* = 7.2 Hz, 1H), 6.55 (t, *J* = 6.9 Hz, 1H), 1.99 (dd, *J* = 7.3 Hz, *J* = 11.8 Hz, 2H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 164.4, 141.0, 134.0, 131.7, 131.6, 128.5, 128.3, 127.3, 127.1, 127.1, 123.3, 50.2, 16.1 (t, *J* = 21.5 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{14}DNNaO_2^+$ $[M+Na]^+$: 325.1058, found 325.1093.



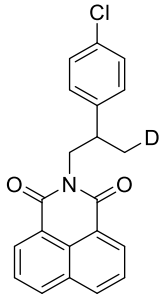
(*R*)-2-(4-methyl-2-(methyl-*d*) pentyl)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4d)

Following GP2 with reaction time of 4 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4d** was obtained in 44% yield as a withe powder with 93% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.61 (d, *J* = 7.3 Hz, 2H), 8.22 (d, *J* = 8.2 Hz, 2H), 7.76 (t, *J* = 7.7 Hz, 2H), 4.07 (t, *J* = 7.1 Hz, 2H), 2.20 (p, *J* = 7.3 Hz, 1H), 1.74 (dt, *J* = 13.6, 6.7 Hz, 1H), 1.22 (td, *J* = 14.0, 13.5, 7.8 Hz, 2H), 0.95 (d, *J* = 6.6 Hz, 3H), 0.90 (dd, *J* = 11.1, 7.0 Hz, 2H), 0.85 (d, *J* = 6.5 Hz, 3H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 164.7, 134.0, 131.7, 131.4, 128.4, 127.1, 122.9, 46.5, 44.4, 29.8, 25.5, 23.6, 22.3, 17.6 (t, *J* = 19.2 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{19}H_{21}DNO_2^+$ $[M+H]^+$: 297.1708, found 297.1648.



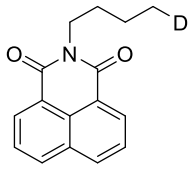
2-(2-(4-chlorophenyl) propyl-3-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4e)

Following GP2 with reaction time of 4 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4e** was obtained in 42% yield as a withe powder with 93% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.57 (d, *J* = 7.3 Hz, 2H), 8.21 (d, *J* = 8.2 Hz, 2H), 7.78 – 7.73 (m, 2H), 7.27 (d, *J* = 8.4 Hz, 2H), 7.23 (d, *J* = 6.4 Hz, 2H), 4.33 (d, *J* = 7.8 Hz, 2H), 3.45 (p, *J* = 7.7 Hz, 1H), 1.31 (d, *J* = 3.1 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.5, 142.7, 134.1, 132.3, 131.7, 131.5, 129.0, 128.6, 128.3, 127.1, 122.6, 46.7, 37.7, 18.6 (t, *J* = 19.8 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{21}H_{15}DClNNaO_2^+$ $[M+Na]^+$: 373.0825, found 373.0866.



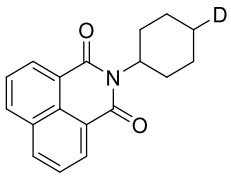
2-(butyl-4-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4f)

Following GP2 and under the irradiation with 390nm LEDs with reaction time of 1 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4f** was obtained in 75% yield as a withe powder with 95% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61 (d, *J* = 7.2 Hz, 2H), 8.21 (d, *J* = 8.2 Hz, 2H), 7.76 (t, J = 7.7 Hz, 2H), 4.19 (t, *J* = 7.6 Hz, 1H), 1.75-1.69 (m, 2H), 1.48-1.43 (m, 2H), 1.00-0.95 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.4, 134.0, 131.8, 131.3, 128.3, 127.1, 122.9, 40.4, 30.4, 20.5, 13.70(t, *J* = 19.1 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{16}H_{15}DNO_2^+$ $[M+H]^+$: 255.1238, found 255.1207.



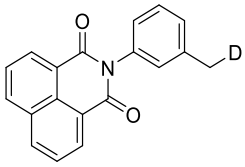
2-(cyclohexyl-4-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4g)

Following GP2 with reaction time of 4 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4g** was obtained in 68% yield as a withe powder with 91% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.57 (d, *J* = 7.2 Hz, 2H), 8.18 (d, *J* = 8.2 Hz, 2H), 7.74 (t, *J* = 7.7 Hz, 2H), 5.06-5.00 (m, 1H), 2.59-2.52 (m, 2H), 1.89 (d, *J* = 12.0 Hz, 2H), 1.73 (overlap, 3H), 1.48-1.41 (m, 2H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 164.8, 133.6, 131.6, 131.2, 128.4, 127.1, 123.5, 53.9, 29.3, 29.2, 26.6, 25.2 (t, *J* = 19.0 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{18}H_{17}DNO_2^+$ $[M+H]^+$: 281.1395, found 281.1392.



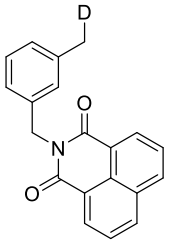
2-(3-(methyl-*d*) phenyl)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4h)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =2:1), compound **4h** was obtained in 83% yield as a withe powder with 95% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.65 (d, *J* = 7.2 Hz, 2H), 8.27 (d, *J* = 8.2 Hz, 2H), 7.79 (t, *J* = 7.7 Hz, 2H), 7.44 (t, *J* = 7.7 Hz, 1H), 7.30 (d, *J* = 7.7 Hz, 1H), 7.13 (overlap, 2H), 2.42 (s, 2H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 164.6, 139.5, 135.5, 134.4, 131.9, 131.7, 129.8, 129.4, 129.3, 128.7, 127.2, 125.7, 123.0, 21.3(t, *J* = 21.5 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{19}H_{12}DNNaO_2^+$ $[M+Na]^+$: 311.0901, found 311.0904.



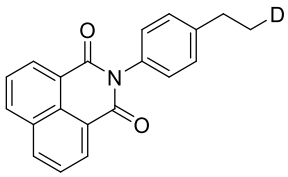
2-(3-(methyl-*d*) benzyl)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4i)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =2:1), compound **4i** was obtained in 67% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.64(d, *J* = 7.2 Hz, 2H), 8.24 (d, *J* = 8.2 Hz, 2H), 7.77 (t, *J* = 7.7 Hz, 2H), 7.19 (d, *J* = 7.5 Hz, 1H), 7.13-7.04 (m, 3H), 5.39 (s, 2H), 2.53 (t, *J* = 2.2 Hz, 2H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 164.5, 135.9, 135.1, 134.3, 131.8, 131.7, 130.5, 128.5, 127.2, 127.1, 126.2, 126.0, 122.8, 41.3, 19.3 (t, *J* = 20.2 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{15}DNO_2^+$ $[M+H]^+$: 303.1238, found 303.1251.



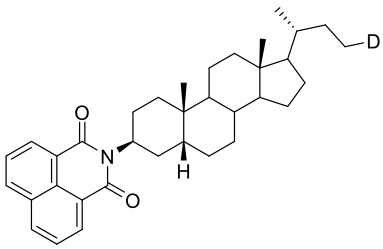
2-(4-(ethyl-2-*d*) phenyl)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4j)

Following GP2 with reaction time of 4 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4j** was obtained in 68% yield as a withe powder with 98% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.65 (d, *J* = 8.5 Hz, 2H), 8.27 (d, *J* = 8.4 Hz, 2H), 7.80 (t, *J* = 7.1 Hz, 2H), 7.38 (d, *J* = 7.9 Hz, 2H), 7.23 (d, *J* = 8.3 Hz, 2H), 2.74 (t, *J* = 7.6 Hz, 2H), 1.29 (t, *J* = 6.6 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.6, 144.8, 134.3, 133.0, 131.9, 131.8, 129.1, 128.7, 128.5, 127.2, 123.1, 28.7, 15.1(t, J = 19.8 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{20}H_{14}DNNaO_2^+$ $[M+Na]^+$: 325.1058, found 325.1080.



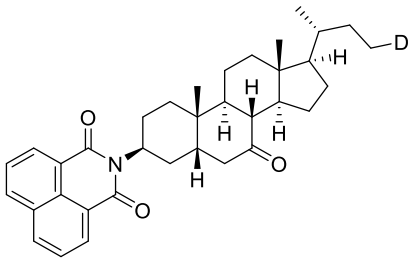
2-((3*S*,5*R*,10*S*,13*R*)-17-((*R*)-butan-2-yl-4-*d*)-10,13-dimethylhexadecahydro-1*H*-cyclopenta[*a*] phenanthren-3-yl)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4k)

Following GP2 and under the irradiation with 390nm LEDs with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4k** was obtained in 52% yield as a withe powder with 94% D-incorporation (determined by ^{1}H NMR)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (dd, *J* = 7.3, 1.1 Hz, 2H), 8.19 (dd, *J* = 8.3, 1.1 Hz, 2H), 7.74 (dd, *J* = 8.2, 7.3 Hz, 2H), 5.25 (dd, *J* = 6.8, 4.8 Hz, 1H), 2.45 – 2.41 (m, 1H), 2.31 (t, *J* = 8.2 Hz, 1H), 2.15 – 2.11 (m, 1H), 2.00 (dt, *J* = 12.6, 3.4 Hz, 1H), 1.85 – 1.69 (m, 5H), 1.67 (dt, *J* = 13.9, 3.6 Hz, 1H), 1.49 – 1.39 (m, 6H), 1.35 – 1.27 (m, 5H), 1.18 – 1.12 (m, 2H), 1.08 (s, 3H), 1.05 – 0.98 (m, 3H), 0.92 (d, *J* = 6.6 Hz, 3H), 0.83 (t, *J* = 7.4 Hz, 2H), 0.68 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.6, 133.5, 131.5, 131.1, 128.2, 126.9, 123.3, 56.8, 55.8, 49.6, 49.4, 42.6, 40.3, 38.0, 37.1, 35.3, 33.9, 30.2, 29.8, 28.3, 28.2, 27.3, 26.5, 24.2, 22.3, 22.2, 21.8, 18.1, 12.1, 9.7 (t, *J* = 21.0 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{35}H_{45}DNO_2^+$ $[M+H]^+$: 513.3586, found 513.3557.



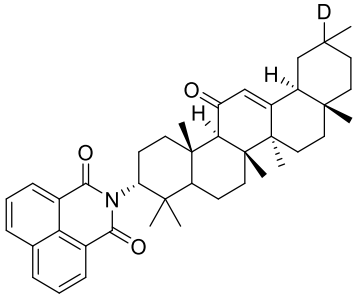
2-((3*S*,5*S*,8*R*,9*S*,10*S*,13*R*,14*S*,17*R*)-17-((*R*)-butan-2-yl-4-*d*)-10,13-dimethyl-7-oxohexadecahydro-1H-cyclopenta[*a*]phenanthren-3-yl)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4l)

Following GP2 and under the irradiation with 390nm LEDs with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =2:1), compound **4l** was obtained in 48% yield as a withe powder with 93% D-incorporation (determined by ^{1}H NMR)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.60 (d, *J* = 7.3 Hz, 2H), 8.23 (d, *J* = 8.2 Hz, 2H), 7.78 (t, *J* = 7.8 Hz, 2H), 5.27 – 5.20 (m, 1H), 2.69 – 2.58 (m, 2H), 2.57 – 2.44 (m, 3H), 2.32 (t, *J* = 11.8 Hz, 1H), 2.23 (dt, *J* = 14.5, 7.6 Hz, 1H), 2.06 (d, *J* = 13.2 Hz, 1H), 1.97 – 1.89 (m, 1H), 1.86 (d, *J* = 14.0 Hz, 1H), 1.74 – 1.62 (m, 3H), 1.52 – 1.46 (m, 2H), 1.38 – 1.28 (m, 8H), 1.17 – 1.06 (m, 4H), 0.95 (d, *J* = 6.6 Hz, 3H), 0.86 (d, *J* = 7.5 Hz, 2H), 0.72 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 214.8, 164.7, 133.7, 131.5, 131.2, 128.2, 127.0, 123.1, 54.5, 49.7, 49.1, 48.6, 47.6, 42.9, 42.6, 39.4, 39.0, 37.0, 36.5, 34.3, 29.5, 28.3, 28.3, 25.7, 23.4, 22.3, 21.7, 18.2, 12.0, 9.9 (t, *J* = 20.8 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{35}H_{42}DNNaO_3^+$ $[M+H]^+$: 549.3198, found 549.3195.



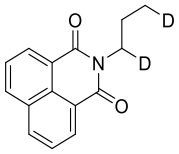
2-((3*R*,6a*R*,6b*S*,8a*R*,11*R*,12a*S*,14a*R*,14b*S*)-4,4,6a,6b,8a,11,14b-heptamethyl-14-oxo-1,2,3,4,4a,5,6,6a,6b,7,8,8a,9,10,11,12,12a,14,14a,14b-icosahydropicen-3-yl-11-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4m)

Following GP2 with reaction time of 4 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4m** was obtained in 51% yield (determined by ^{1}H NMR) as a withe powder with 83% D-incorporation (determined by HRMS)

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.59 (d, *J* = 8.5 Hz, 1H), 8.53 (d, *J* = 7.3 Hz, 1H), 8.18 (t, *J* = 6.8 Hz, 2H), 7.78 – 7.70 (m, 2H), 5.65 (d, *J* = 14.1 Hz, 1H), 5.51 (d, *J* = 11.1 Hz, 1H), 2.85 – 2.76 (m, 1H), 2.67 (s, 1H), 2.32 (q, *J* = 8.5, 7.0 Hz, 1H), 2.26 – 1.94 (m, 4H), 1.90 – 1.82 (m, 1H), 1.76 – 1.72 (m, 4H), 1.56 – 1.52 (m, 2H), 1.47 (s, 3H), 1.44 (s, 3H), 1.41 – 1.35 (m, 2H), 1.30 – 1.20 (m, 5H), 1.16 (s, 3H), 1.00 (s, 6H), 0.92 – 0.82 (m, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 200.0, 170.8, 166.1, 165.4, 133.4, 133.3, 131.5, 131.4, 131.0, 128.2, 128.0, 127.0, 126.9, 123.8, 123.1, 63.2, 57.5, 51.8, 50.7, 45.6, 43.6, 41.9, 41.6, 41.5, 40.9, 39.7, 36.7, 32.5, 32.2, 29.7, 28.8, 26.7, 26.7, 26.6 (t, *J* = 21.3 Hz, C-D), 26.1, 25.3, 24.7, 23.4, 21.7, 19.3, 18.4.

HRMS (ESI-TOF, m/z): calcd for $C_{41}H_{51}DNO_3^+$ $[M+H]^+$: 607.4004, found 607.3996.



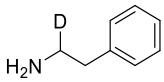
2-(propyl-1,3-*d*$_2$)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (4v)

Following GP2 with reaction time of 4 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **4m** was obtained in 41% yield (determined by ^{1}H NMR) as a withe powder with 95% D-incorporation (determined by ^{1}H NMR)

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.61 (d, *J* = 7.3 Hz, 2H), 8.21 (d, *J* = 8.3 Hz, 2H), 7.79 – 7.71 (m, 2H), 4.16 – 4.11 (m, 1H), 1.76 (q, *J* = 7.6 Hz, 2H), 1.02 – 0.98 (m, 2H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 164.4, 134.0, 131.7, 131.3, 128.3, 127.1, 122.9, 41.8 (t, *J* = 21.4 Hz, C-D), 21.4, 11.4 (t, *J* = 19.5 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{15}H_{12}D_2NO_2^+$ $[M+H]^+$: 242.1145, found 242.1132.



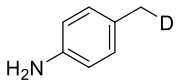
2-phenylethan-1-*d*-1-amine (5a)

After purified by column chromatography on silica gel (eluent: DCM/MeOH =10:1), compound **5a** was obtained in 62% yield with 96% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 7.28 (t, *J* = 7.5 Hz, 2H), 7.23 – 7.18 (m, 3H), 3.06 (t, *J* = 8.2 Hz, 1H), 2.91 (d, *J* = 7.6 Hz, 2H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 137.7, 128.9, 127.0, 41.2(t, *J* = 21.6 Hz, C-D), 35.6.

HRMS (ESI-TOF, m/z): calcd for $C_8H_{11}DN^+$ $[M+H]^+$: 123.1027, found 123.1013.



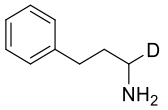
4-(methyl-*d*) aniline (5b)

After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **5b** was obtained in 86% yield with 98% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 6.99 (d, *J* = 7.9 Hz, 2H), 6.70 (d, *J* = 7.8 Hz, 2H), 2.24 (s, 2H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 143.9, 129.9, 127.9, 115.4, 20.3 (t, *J* = 19.2 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_7H_9DN^+$ $[M+H]^+$: 109.0871, found 109.0886.



3-phenylpropan-1-*d*-1-amine (5m)

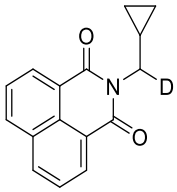
After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =1:1), compound **5m** was obtained in 67% yield as a yellow oil with 95% D-incorporation (determined by

^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.30 – 7.26 (m, 2H), 7.19 (m, 3H), 2.71 (dt, *J* = 10.4, 5.4 Hz, 1H), 2.66 (t, *J* = 7.8 Hz, 2H), 1.77 (dd, *J* = 14.5, 6.9 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 142.1, 128.5, 125.9, 41.4 (t, *J* = 20.9 Hz, C-D), 35.0, 33.3.

HRMS (ESI-TOF, m/z): calcd for $C_9H_{13}DN^+$ $[M+H]^+$: 137.1184, found 137.1180.



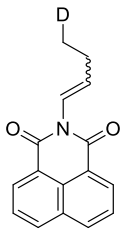
2-(cyclopropylmethyl-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (6c)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =4:1), compound **6c** was obtained in 44% yield as a withe powder with 98% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61 (d, *J* = 8.4 Hz, 2H), 8.21 (d, *J* = 8.3 Hz, 2H), 7.78 – 7.73 (m, 2H), 4.08 (d, *J* = 7.2 Hz, 1H), 1.36 (h, *J* = 6.7 Hz, 1H), 0.50 (d, *J* = 6.4 Hz, 4H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.5, 133.8, 131.6, 131.2, 128.3, 126.9, 122.9, 44.4 (t, *J* = 21.9 Hz, C-D), 10.2, 3.9.

HRMS (ESI-TOF, m/z): calcd for $C_{16}H_{13}DNO_2^+$ $[M+H]^+$: 253.1082, found 253.1077.



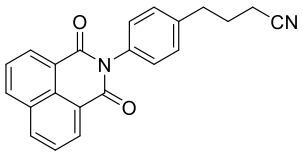
2-(but-1-en-1-yl-4-*d*)-1*H*-benzo[*de*]isoquinoline-1,3(2*H*)-dione (6d)

Following GP1 with reaction time of 3 d. After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =4:1), compound **6d** was obtained in 7% yield as a withe powder with 99% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.63 (t, *J* = 7.7 Hz, 2H), 8.23 (dd, *J* = 12.3, 8.1 Hz, 2H), 7.78 (q, *J* = 7.7 Hz, 2H), 6.27 (d, *J* = 8.5 Hz, 1H), 5.94 (q, *J* = 7.6 Hz, 1H), 2.01 (q, *J* = 7.5 Hz, 2H), 1.02 (q, *J* = 10.4, 9.0 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 163.6, 135.4, 134.1, 134.0, 131.5, 131.2, 127.0, 127.0, 122.7, 119.7, 21.0, 12.7 (t, *J* = 19.2 Hz, C-D).

HRMS (ESI-TOF, m/z): calcd for $C_{16}H_{12}DNNaO_2^+$ $[M+Na]^+$: 275.0901, found 275.0913.



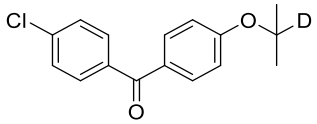
4-(4-(1,3-dioxo-1H-benzo[*de*]isoquinolin-2(3*H*)-yl) phenyl) butanenitrile (6e)

After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =3:1), compound **6e** was obtained in 33% yield as a withe powder (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 8.65 (d, *J* = 7.3 Hz, 2H), 8.28 (d, *J* = 8.3 Hz, 2H), 7.80 (t, *J* = 7.9 Hz, 2H), 7.38 (d, *J* = 8.2 Hz, 2H), 7.27 (d, *J* = 7.9 Hz, 2H), 2.88 (t, *J* = 7.3 Hz, 2H), 2.41 (t, *J* = 7.2 Hz, 2H), 2.06 (m, 2H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 164.4, 140.3, 134.4, 133.8, 131.8, 131.7, 129.5, 128.9, 128.6, 127.1, 122.8, 119.5, 34.2, 26.8, 16.6.

HRMS (ESI-TOF, m/z): calcd for $C_{22}H_{17}N_2O_2^+$ $[M+H]^+$: 341.1285, found 341.1311.



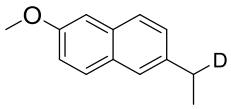
(4-chlorophenyl) (4-((propan-2-yl-2-*d*) oxy) phenyl) methanone (6f)

After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =9:1), compound **6f** was obtained in 89% yield as a withe powder with 95% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 7.77 (d, *J* = 8.4 Hz, 2H), 7.71 (d, *J* = 8.1 Hz, 2H), 7.45 (d, *J* = 8.1 Hz, 2H), 6.93 (d, *J* = 8.4 Hz, 2H), 1.38 (s, 6H)..

^{13}C NMR (151 MHz, CDCl$_3$) δ 194.3, 162.0, 138.2, 136.7, 132.5, 131.2, 129.3, 128.5, 115.0, 69.8 (t, *J* = 22.2 Hz, C-D), 21.8.

HRMS (ESI-TOF, m/z): calcd for $C_{16}H_{15}DClO_2^+$ $[M+H]^+$: 276.0896, found 276.0890.



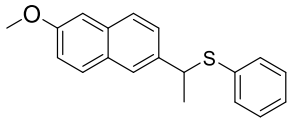
2-(ethyl-1-*d*)-6-methoxynaphthalene (6g)

After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =30:1), compound **6g** was obtained in 12% yield as a withe powder with 79% D-incorporation (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 7.71 (dd, *J* = 8.5, 4.5 Hz, 2H), 7.60 (s, 1H), 7.36 (d, *J* = 8.3 Hz, 1H), 7.16 (d, *J* = 9.1 Hz, 2H), 3.95 (s, 3H), 2.82 (d, *J* = 7.6 Hz, 1H), 1.36 (t, 7.5 Hz, 3H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 157.2, 139.6, 133.0, 129.3, 129.0, 127.7, 126.8, 125.6, 118.7, 105.8, 55.4, 28.6 (t, *J* = 18.5 Hz, C-D), 15.8.

HRMS (ESI-TOF, m/z): calcd for $C_{13}H_{14}DO^+$ $[M+H]^+$: 188.1180, found 188.1188.



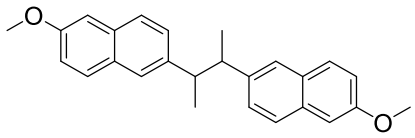
(1-(6-methoxynaphthalen-2-yl) ethyl) (phenyl) sulfane (6h)

After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =9:1), compound **6h** was obtained in 7% yield as a withe powder (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 7.71 (d, *J* = 8.4 Hz, 1H), 7.66 (d, *J* = 8.6 Hz, 1H), 7.58 (s, 1H), 7.51 (d, *J* = 8.4 Hz, 1H), 7.31 (d, *J* = 5.2 Hz, 2H), 7.24 – 7.18 (m, 3H), 7.13 (d, *J* = 8.5 Hz, 2H), 4.50 (q, *J* = 7.0 Hz, 1H), 3.94 (s, 3H), 1.72 (d, *J* = 7.0 Hz, 3H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 157.8, 138.4, 135.3, 133.9, 132.7, 129.4, 128.8, 128.8, 127.3, 127.2, 126.3, 125.8, 119.0, 105.8, 55.5, 48.3, 22.5.

HRMS (ESI-TOF, m/z): calcd for $C_{19}H_{18}NaOS^+$ $[M+H]^+$: 317.0971, found 317.0986.



6,6'-(butane-2,3-diyl) bis (2-methoxynaphthalene) (6i)

After purified by column chromatography on silica gel (eluent: petroleum ether/EtOAc =9:1), compound **6i** was obtained in 23% yield as a withe powder (determined by ^{1}H NMR).

^{1}H NMR (600 MHz, CDCl$_3$) δ 7.72 (m, 4H), 7.62 (s, 2H), 7.38 (d, *J* = 6.7 Hz, 2H), 7.15 (d, *J* = 6.6 Hz, 4H), 3.93 (s, 6H), 3.05 – 3.01 (m, 2H), 1.11 (d, *J* = 5.8 Hz, 6H).

^{13}C NMR (151 MHz, CDCl$_3$) δ 157.4, 141.9, 133.4, 129.2, 126.9, 126.7, 126.1, 118.8, 105.8, 55.5, 47.3, 21.4.

HRMS (ESI-TOF, m/z): calcd for $C_{26}H_{27}O_2^+$ $[M+H]^+$: 371.2006, found 371.1986.

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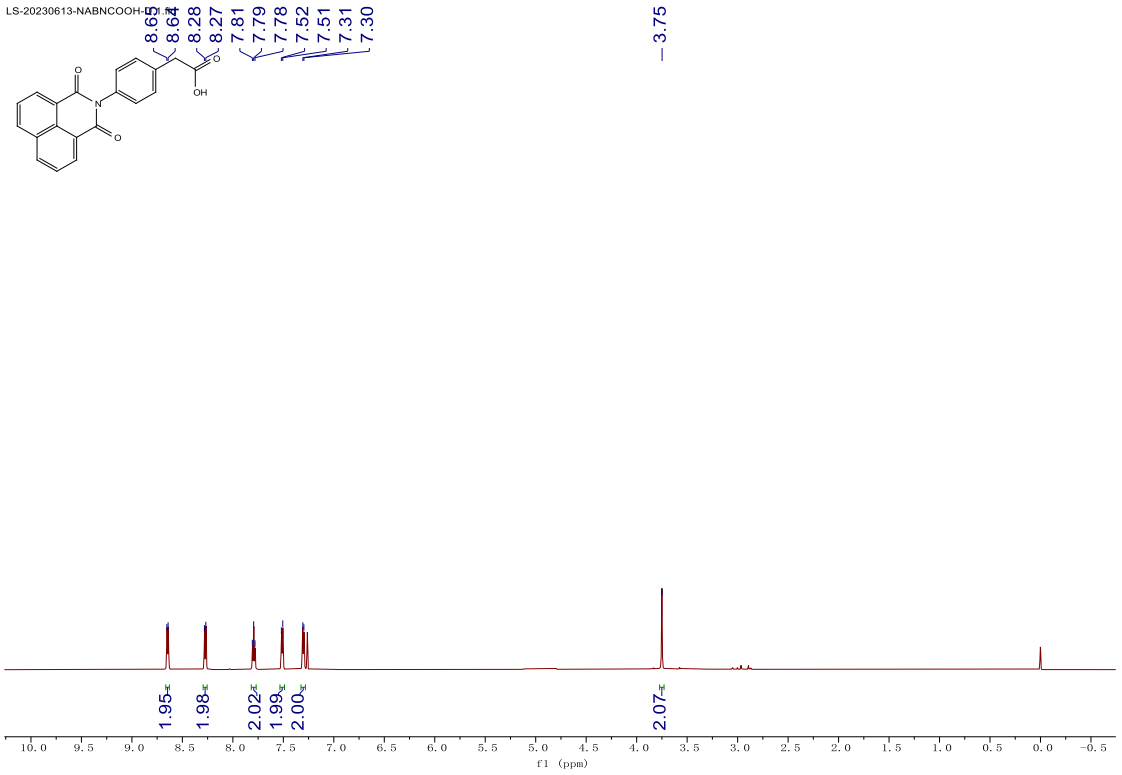
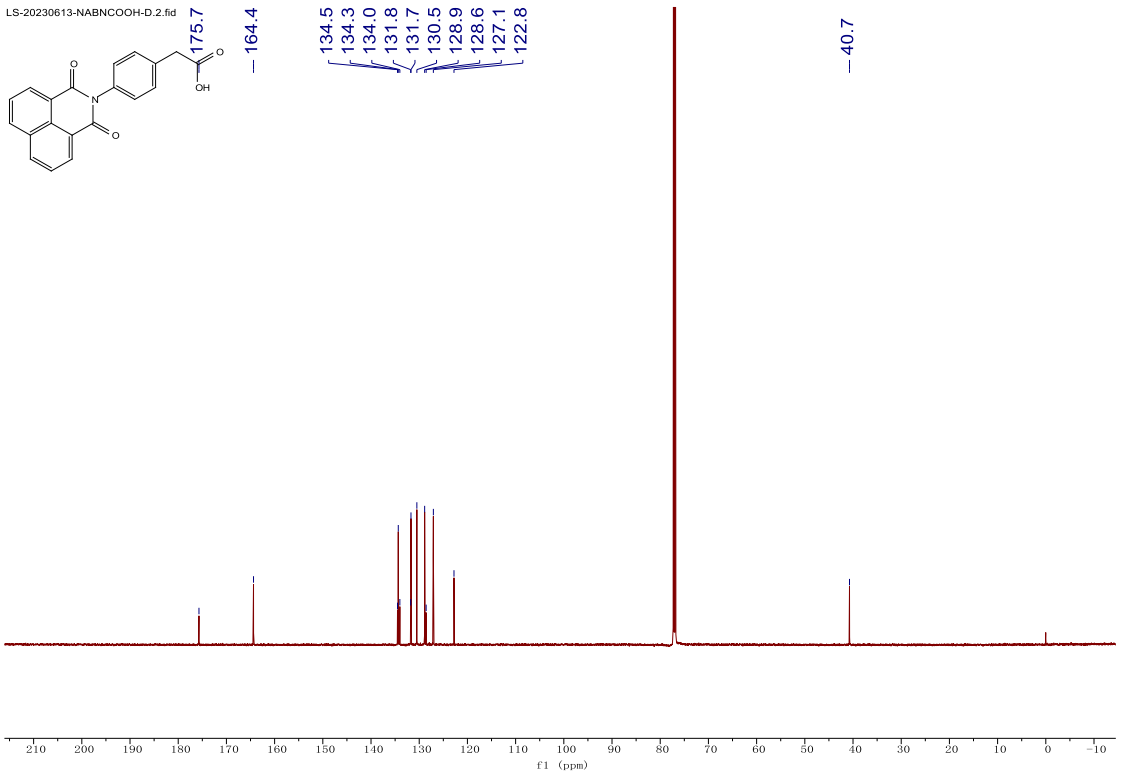
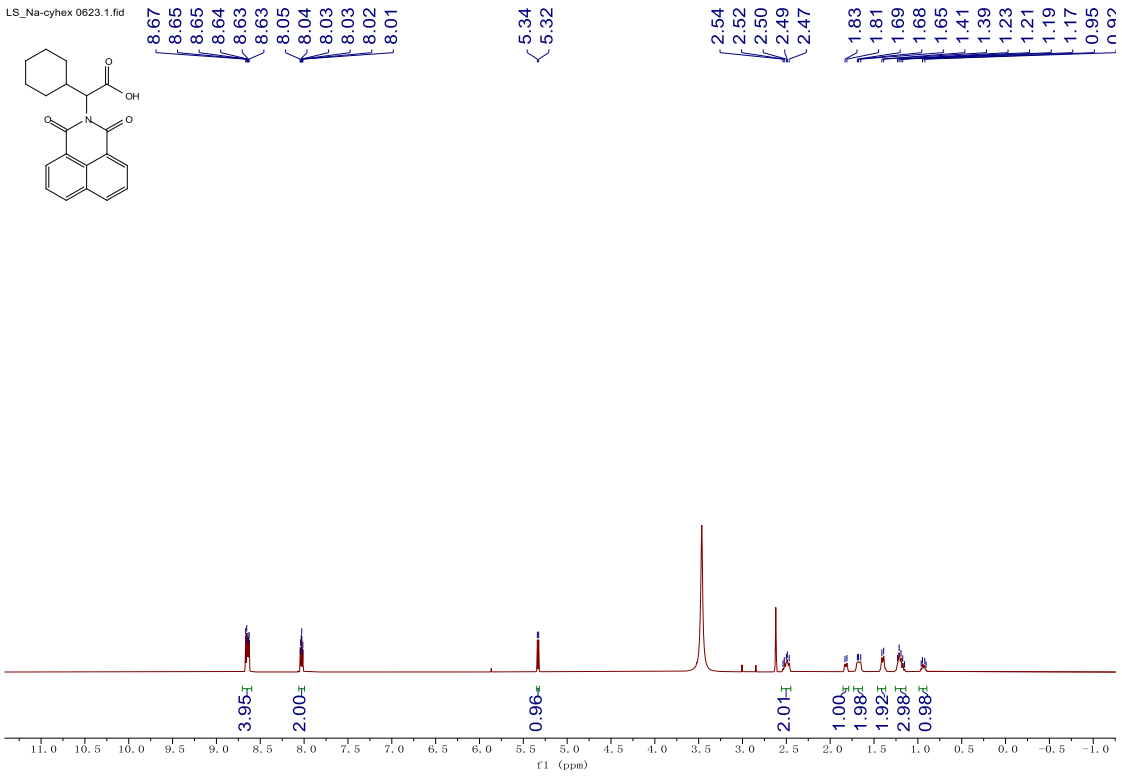
NMR spectra



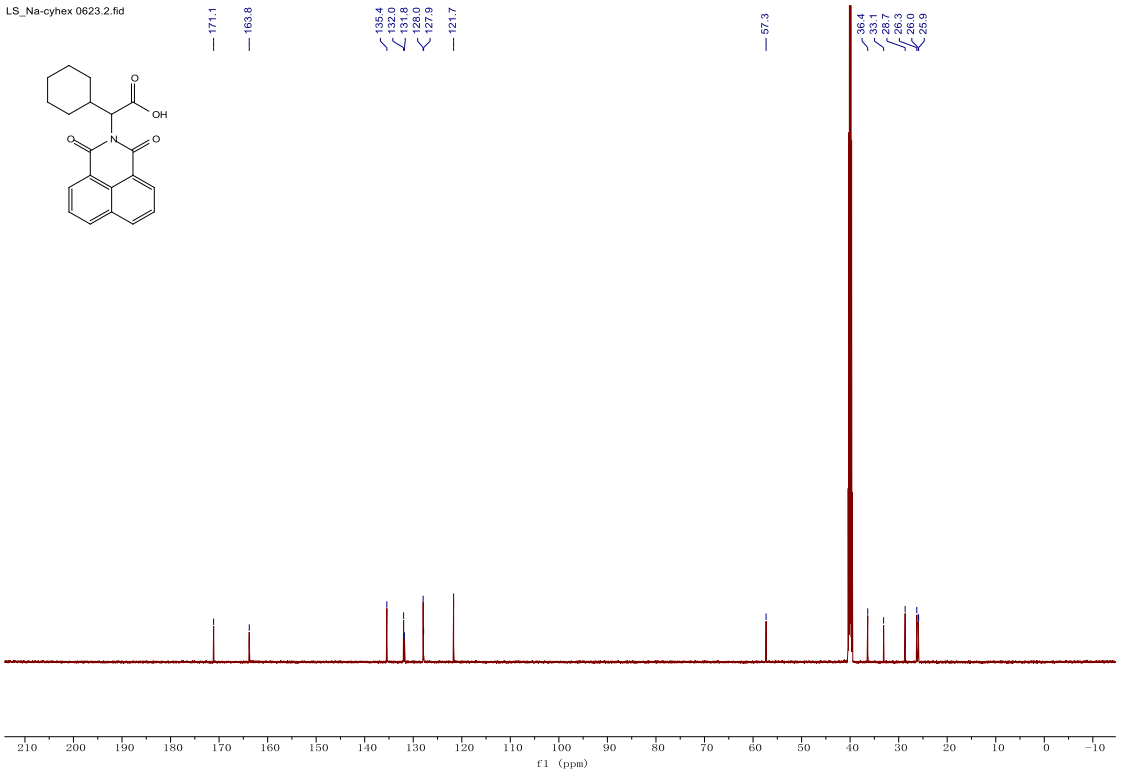
^{1}H NMR spectrum for compound **1b**



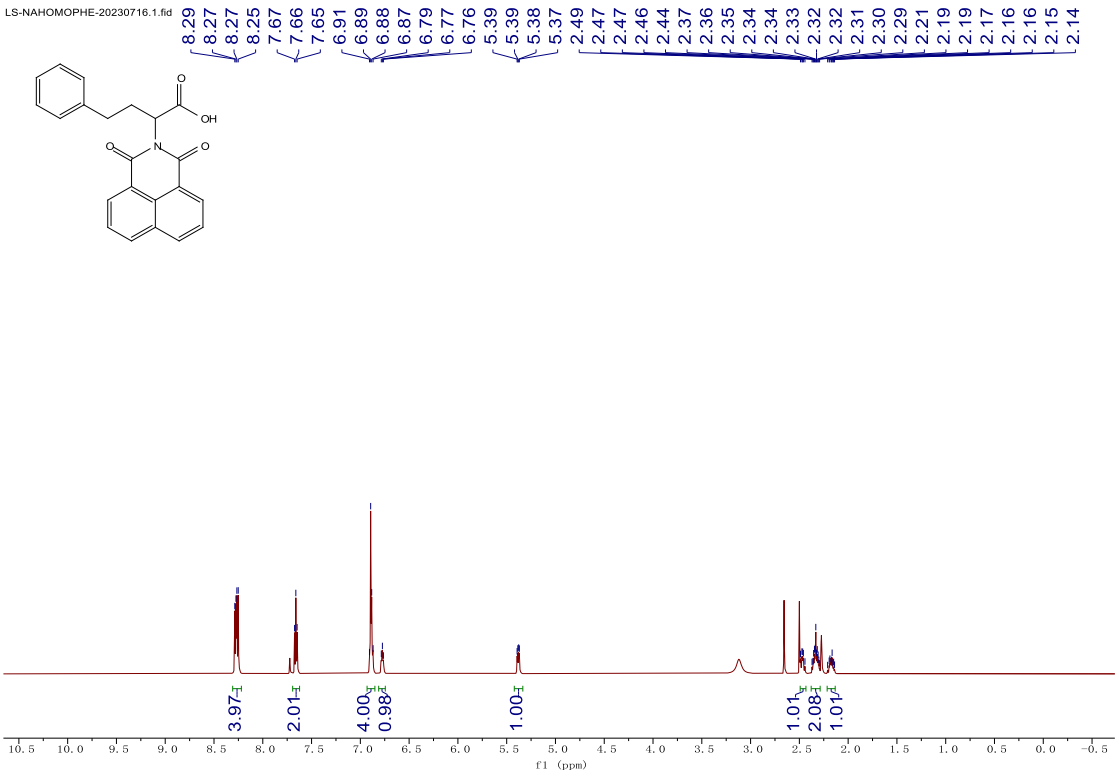
^{13}C NMR spectrum for compound **1b**



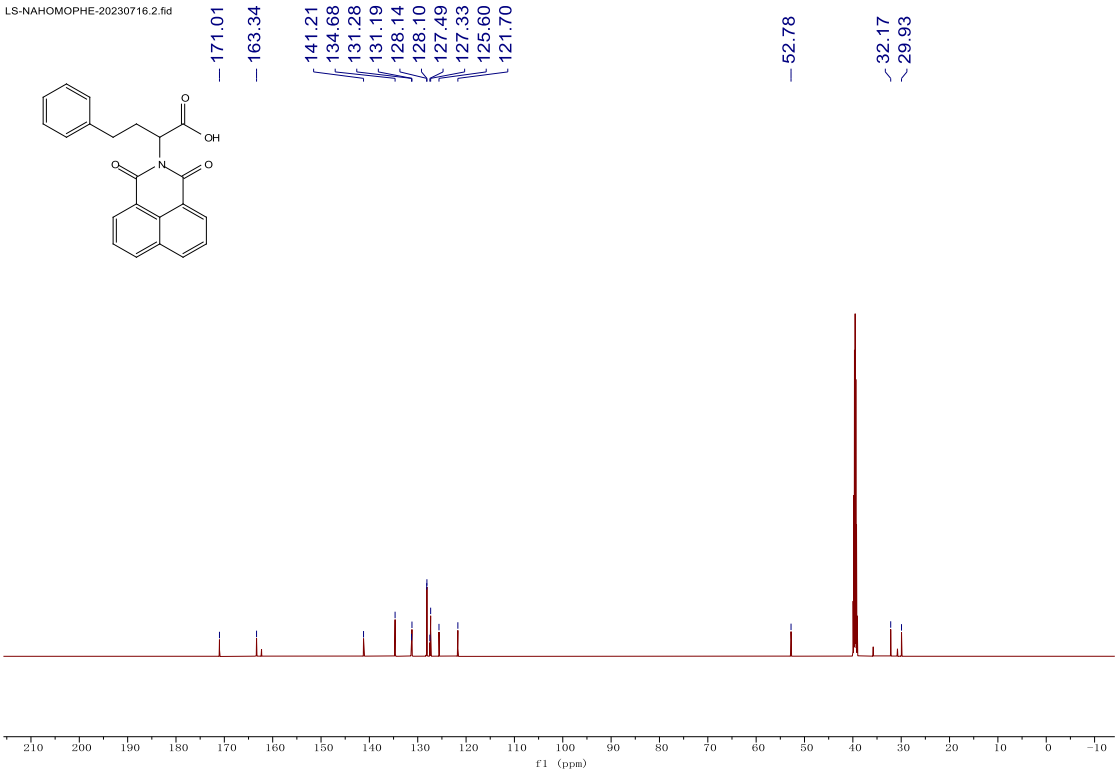
^{1}H NMR spectrum for compound **1j**



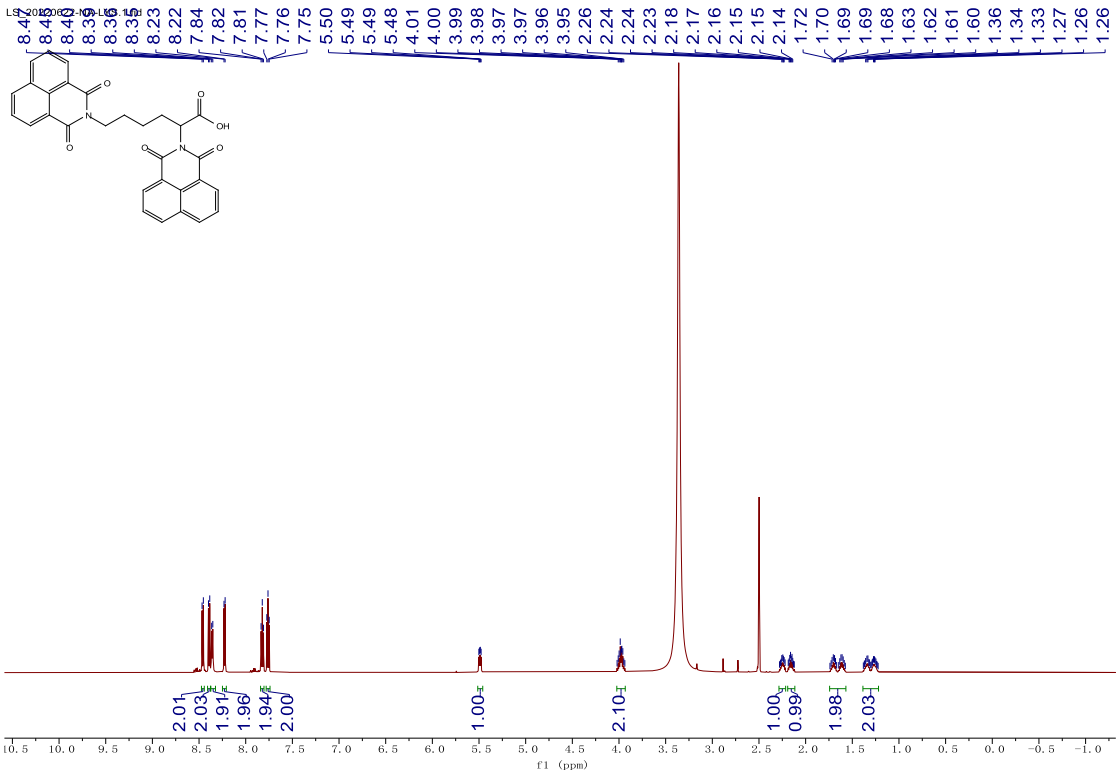
^{13}C NMR spectrum for compound **1j**



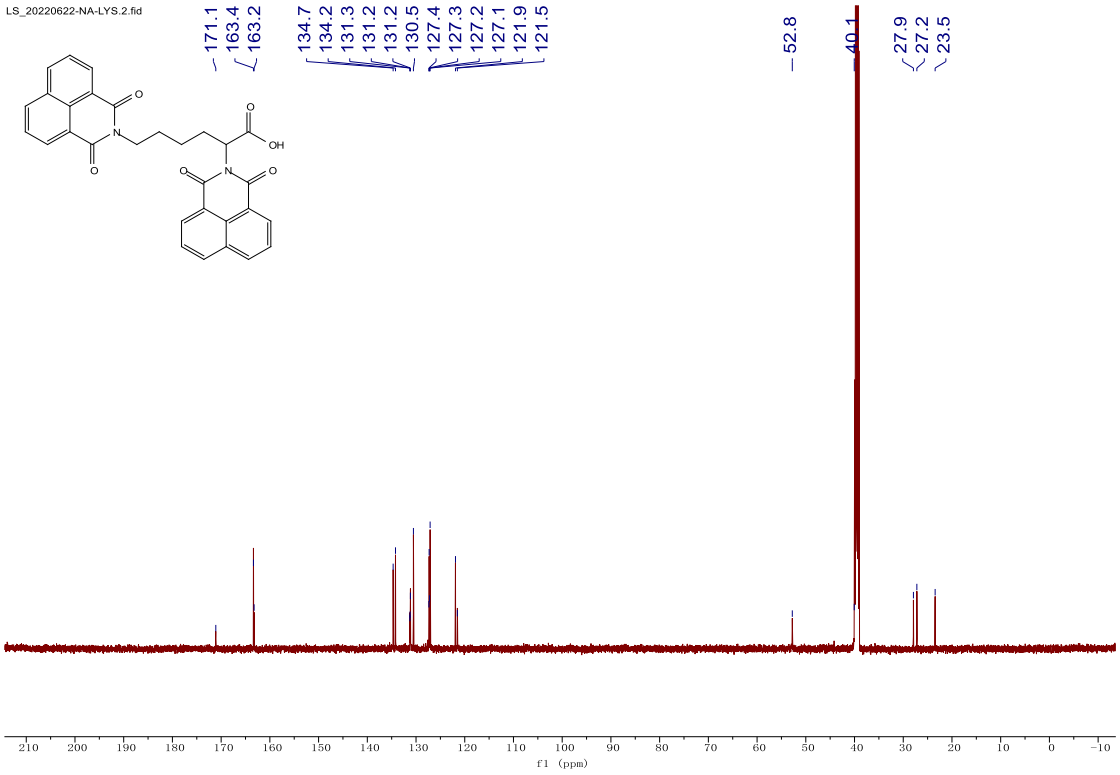
^{1}H NMR spectrum for compound **1m**



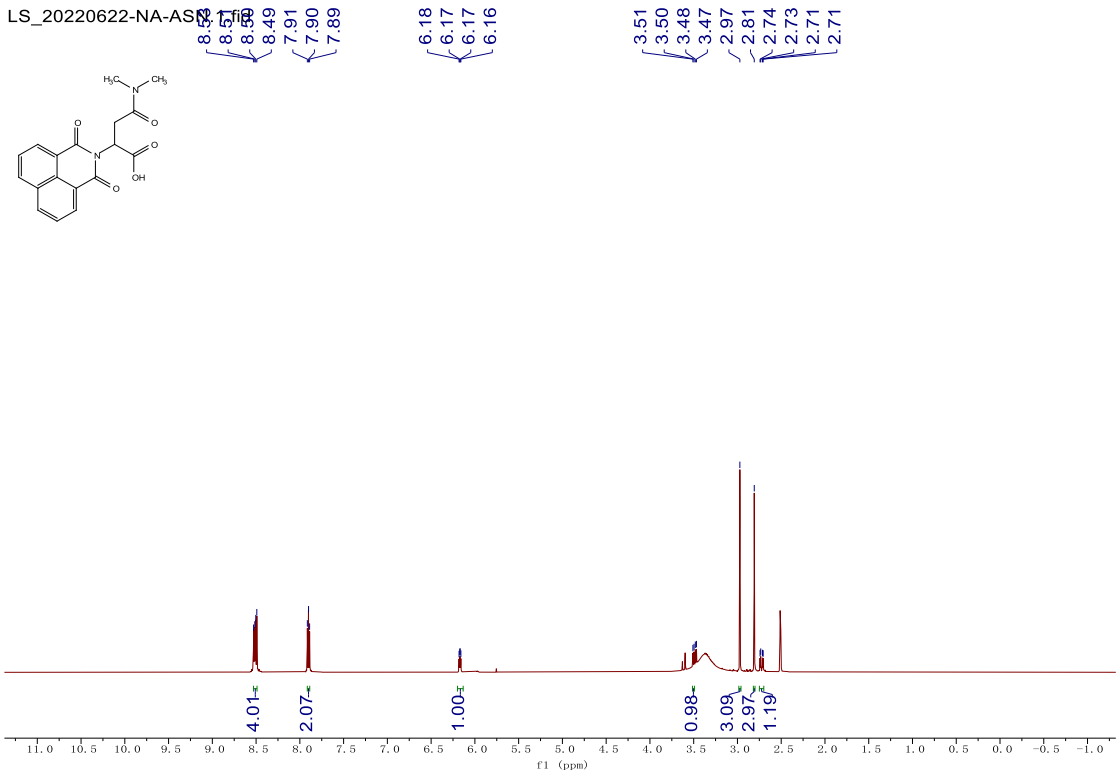
^{13}C NMR spectrum for compound **1m**



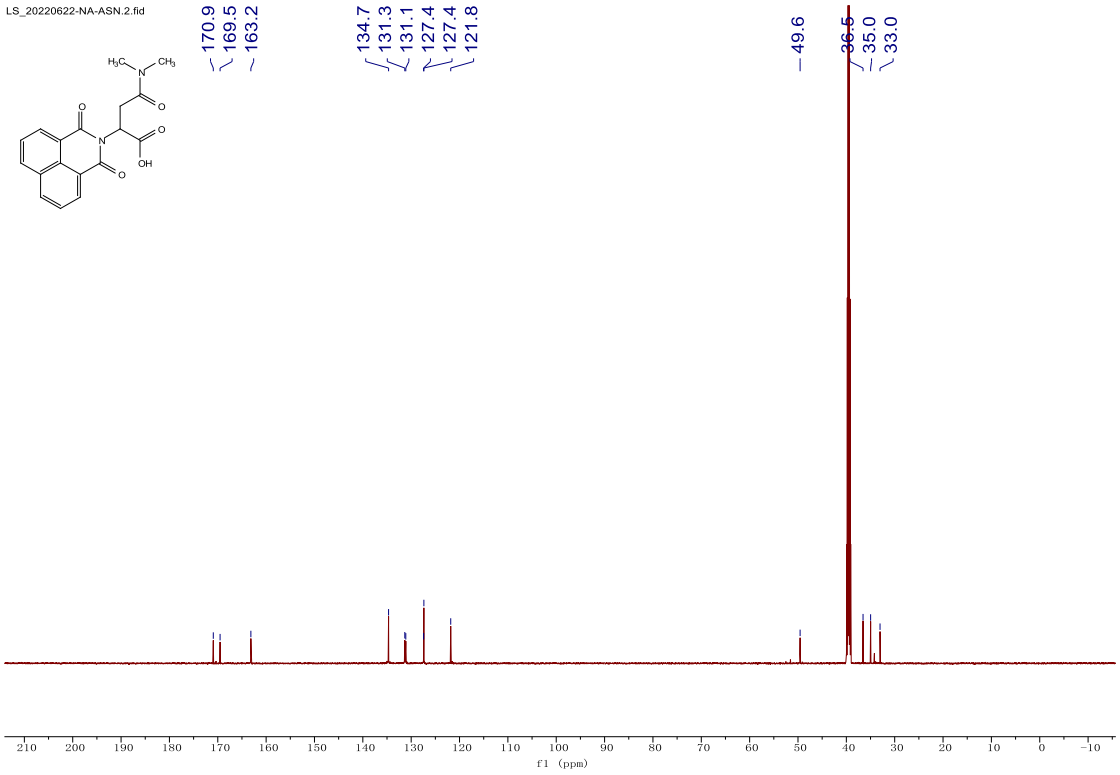
^{1}H NMR spectrum for compound **1n**



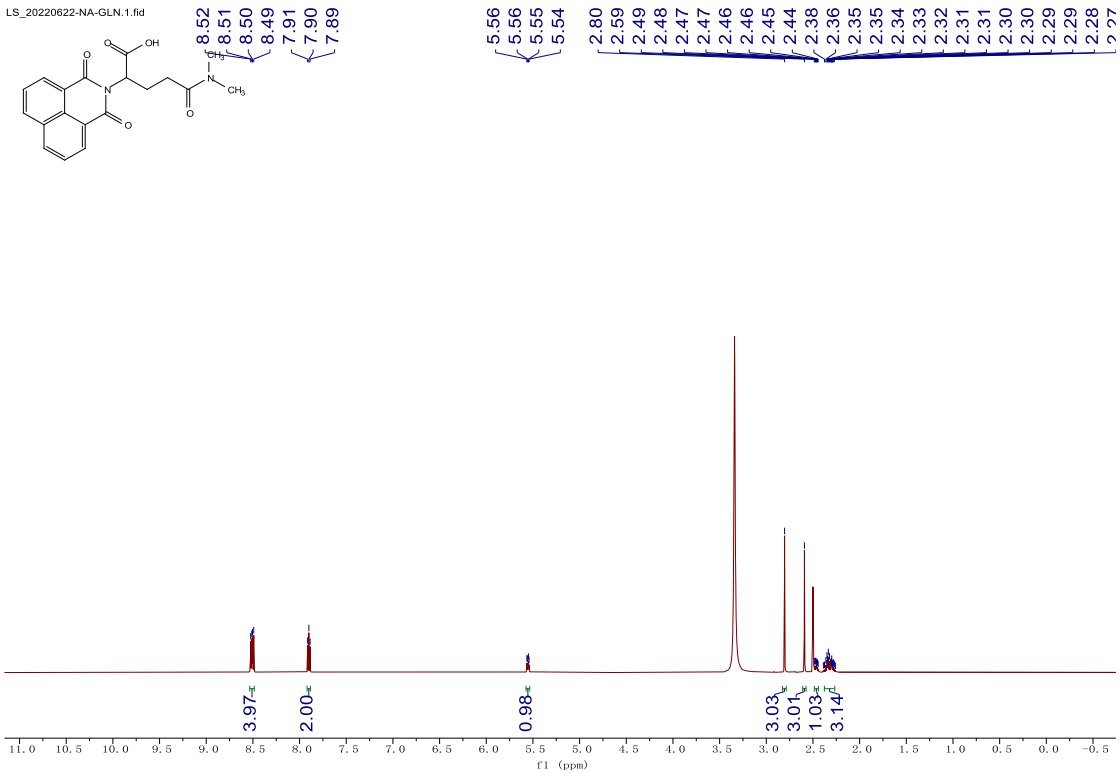
^{13}C NMR spectrum for compound **1n**



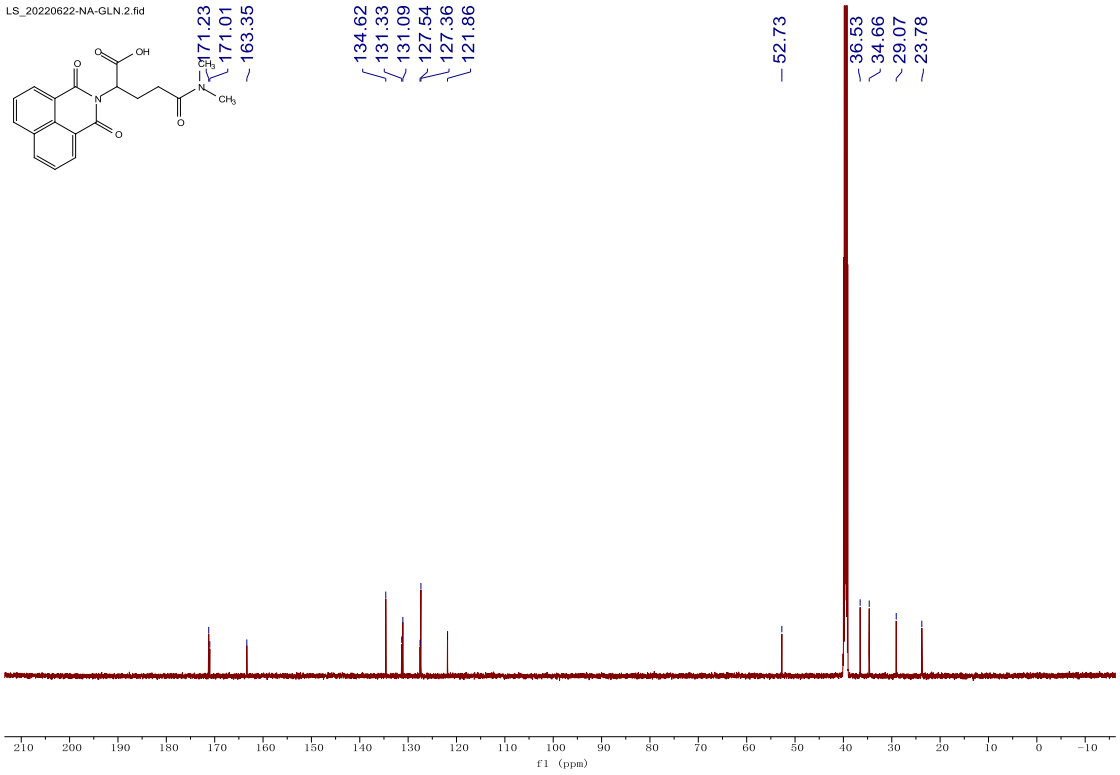
^{1}H NMR spectrum for compound **1p**



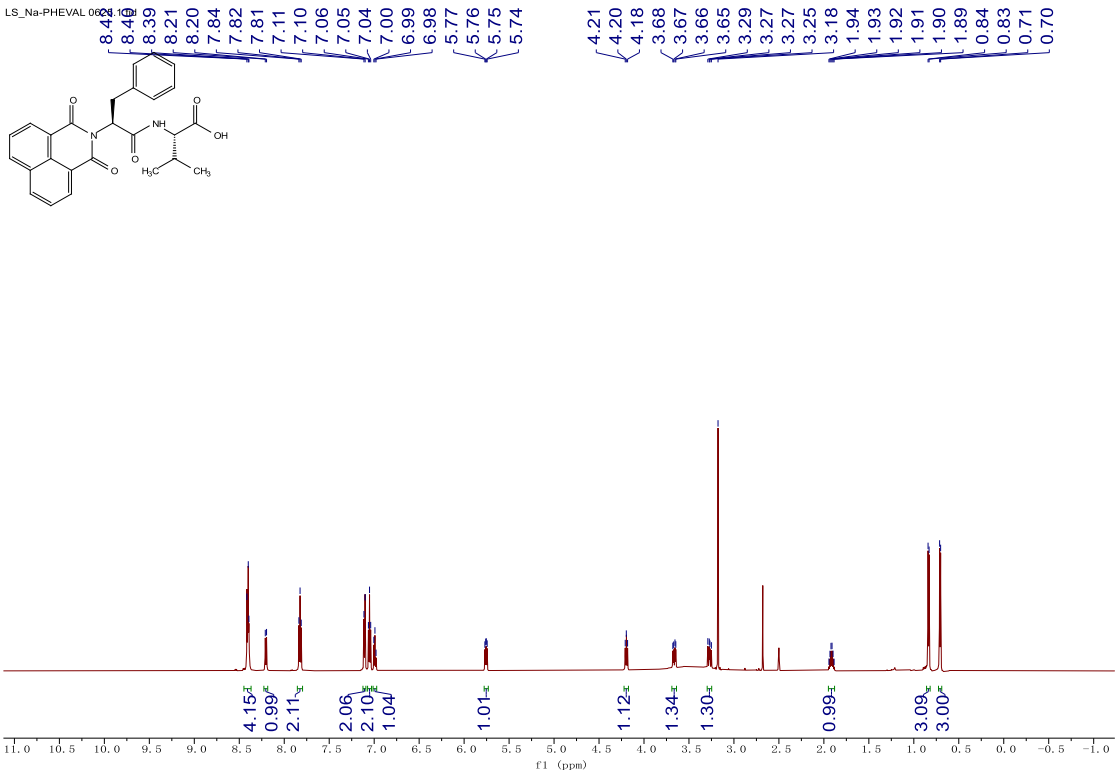
^{13}C NMR spectrum for compound **1p**



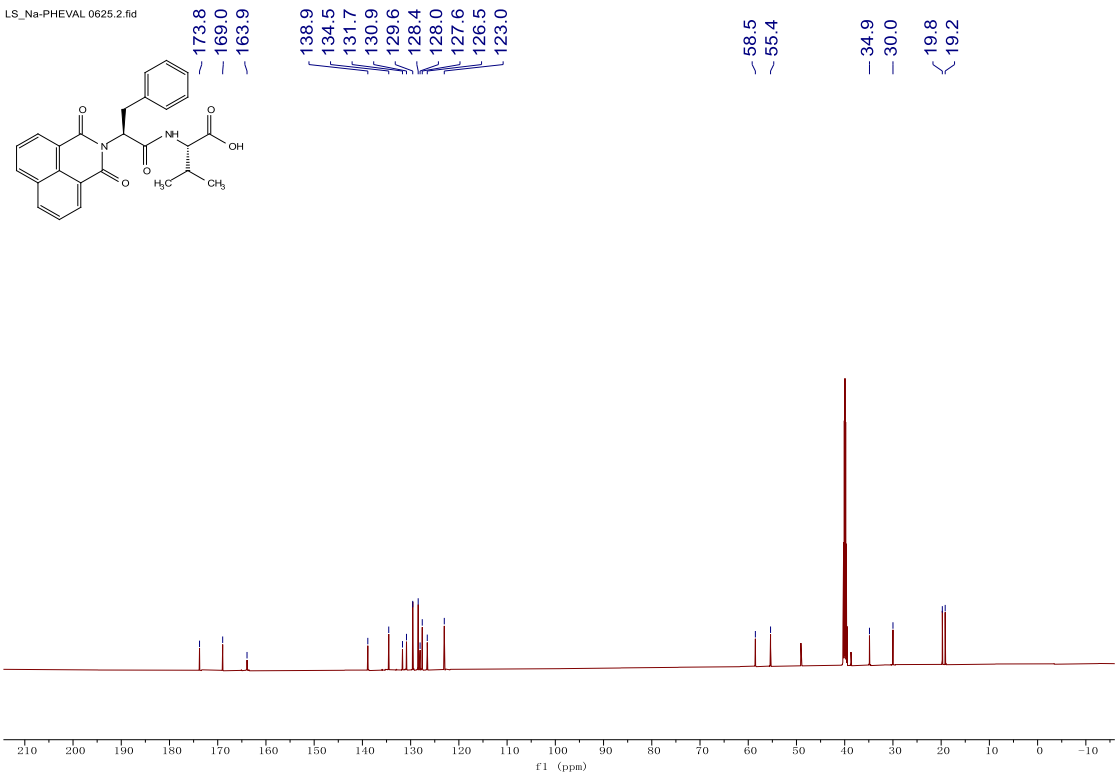
^{1}H NMR spectrum for compound **1q**



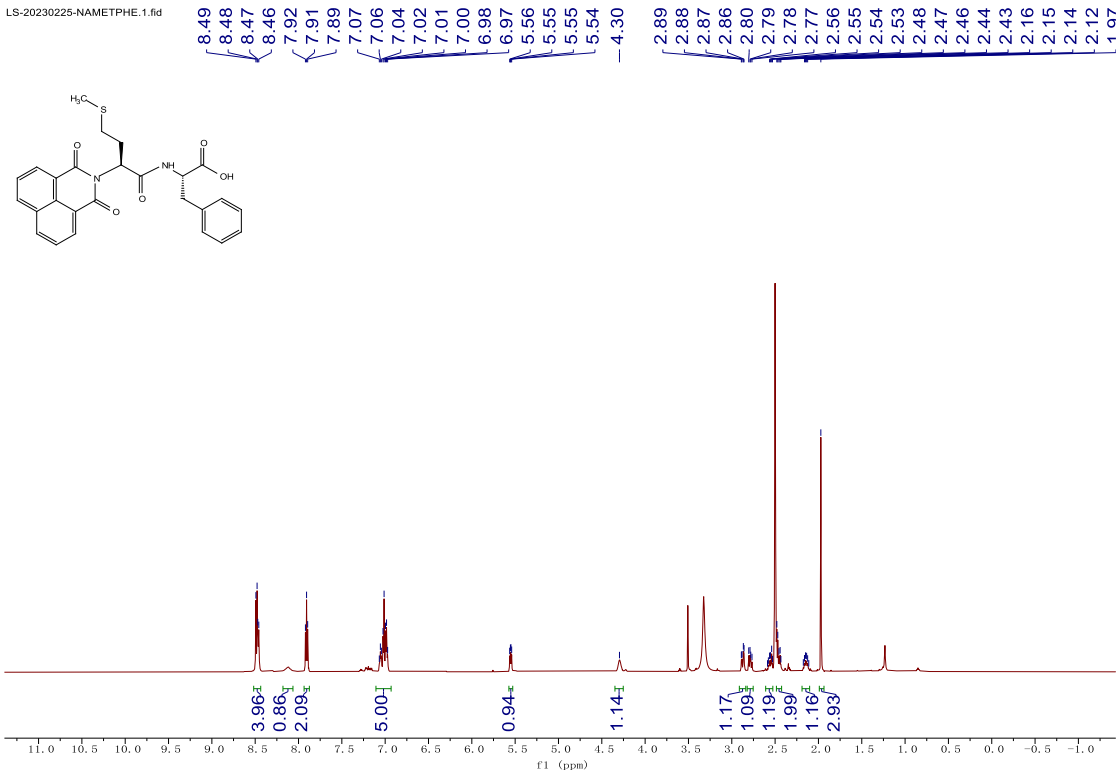
^{13}C NMR spectrum for compound **1q**



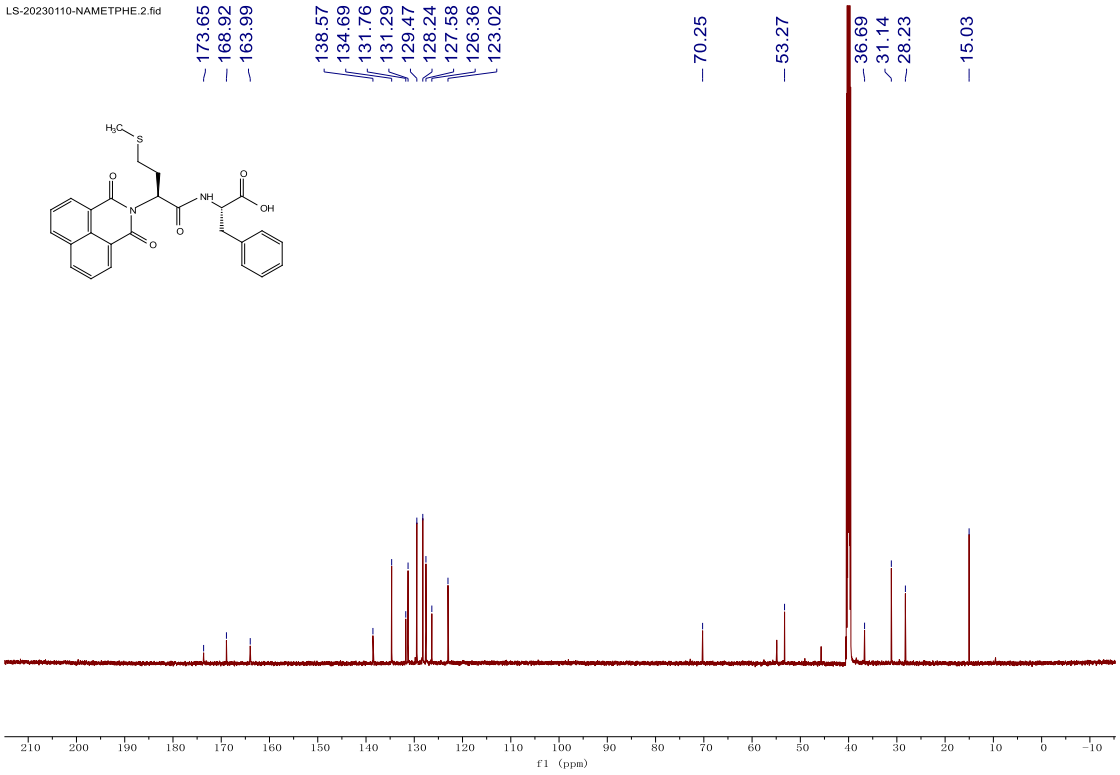
^{1}H NMR spectrum for compound **1w**



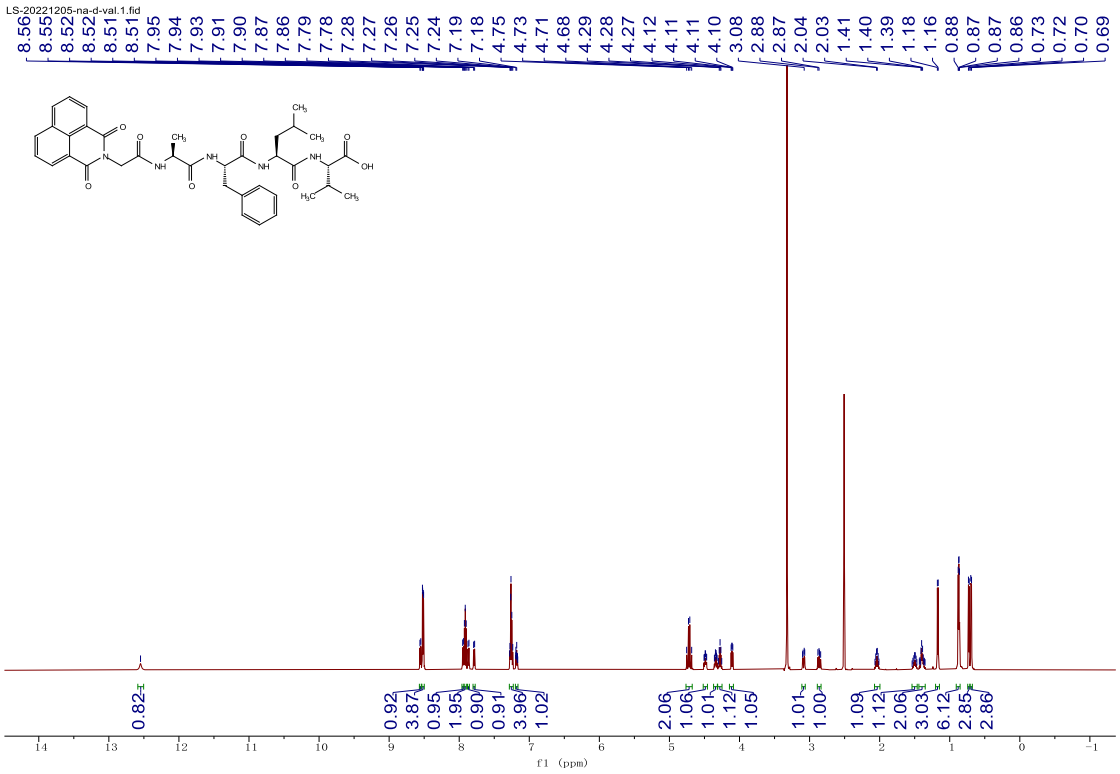
^{13}C NMR spectrum for compound **1w**



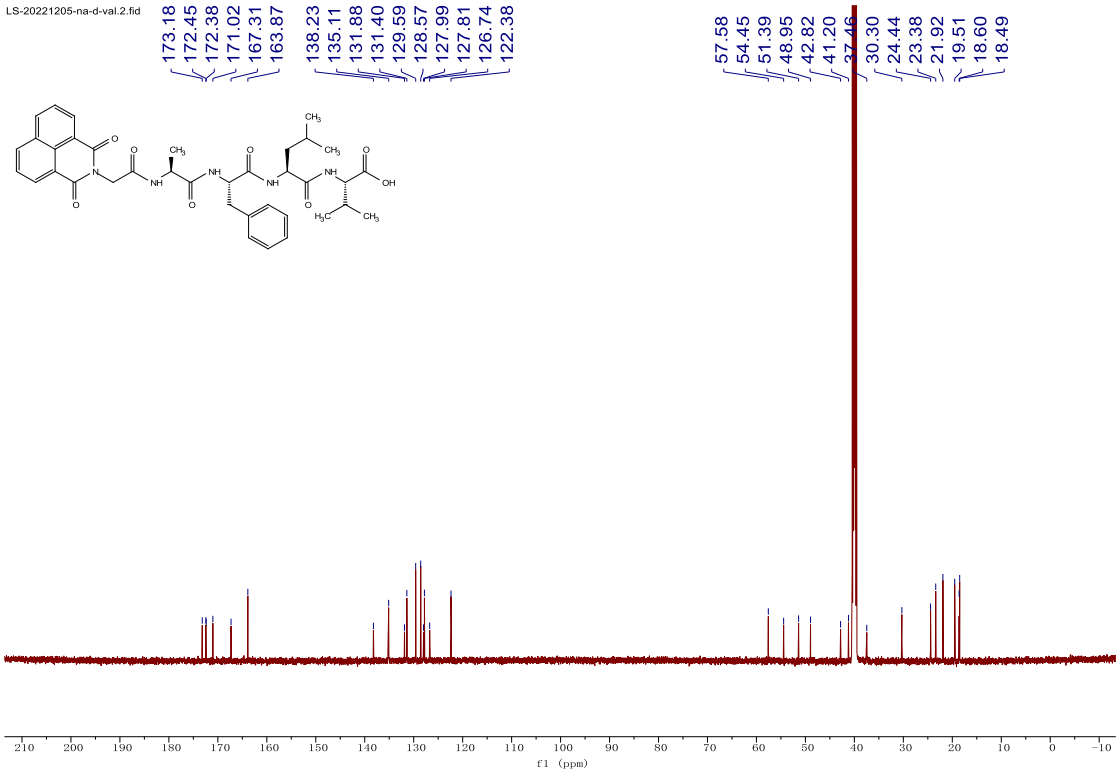
^{1}H NMR spectrum for compound **1x**



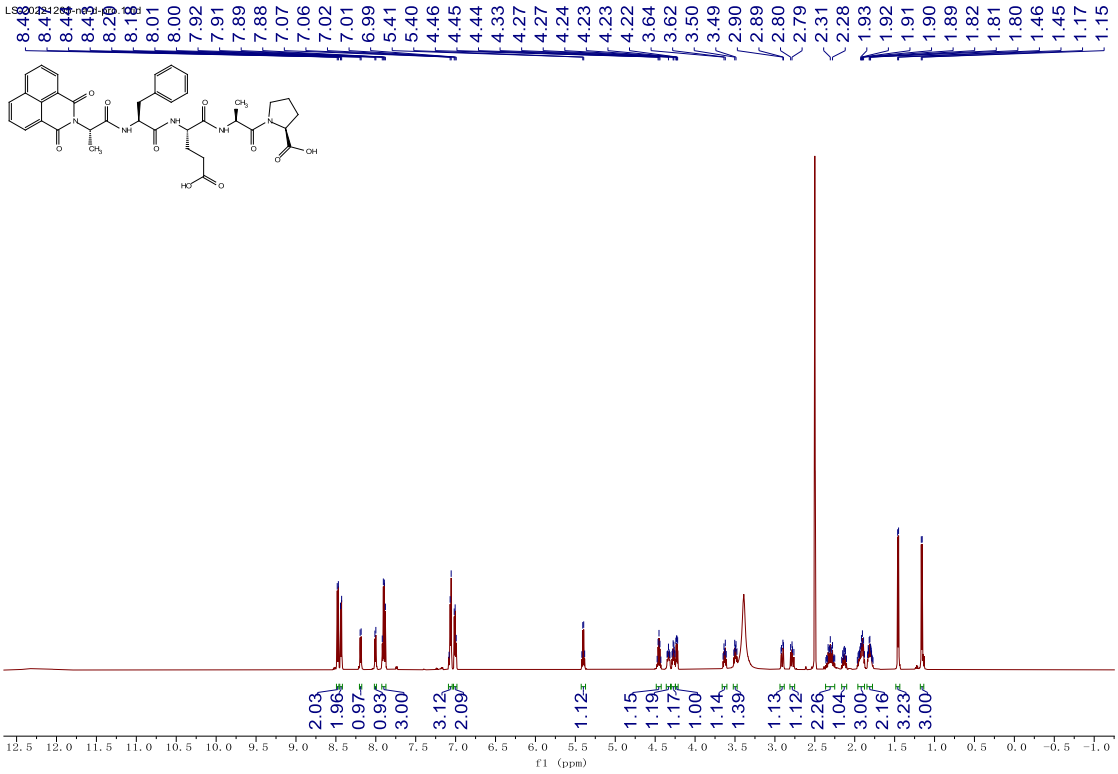
^{13}C NMR spectrum for compound **1x**



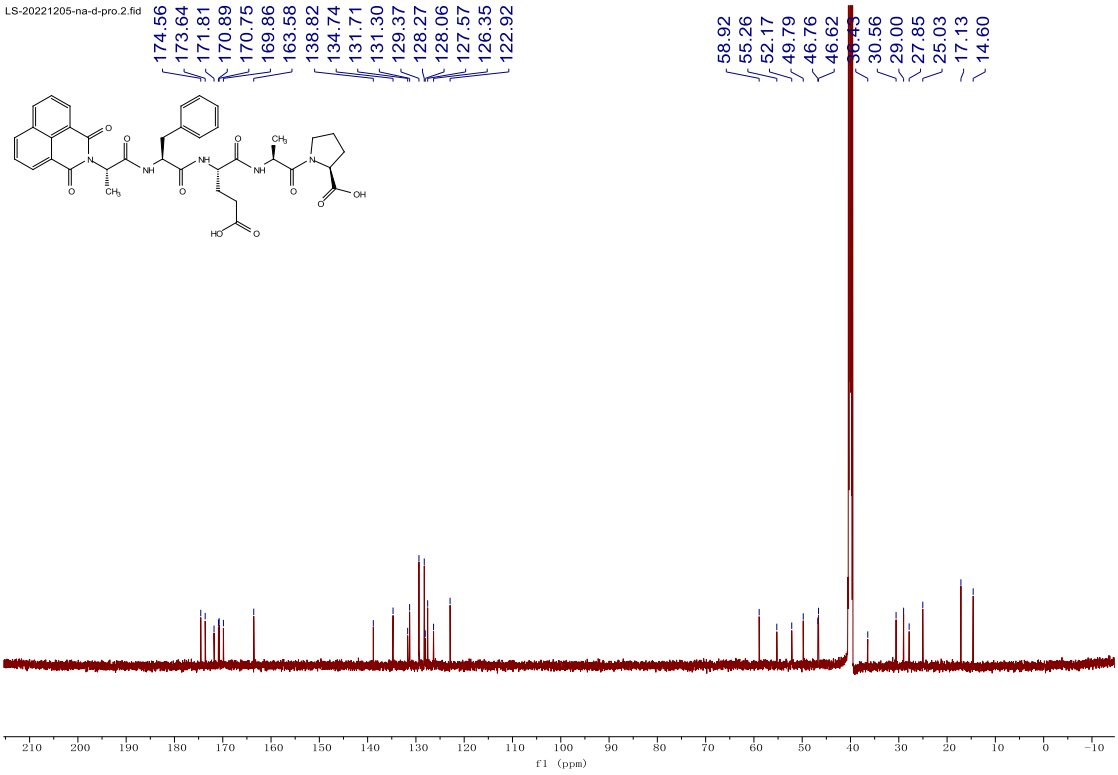
^{1}H NMR spectrum for compound **1y**



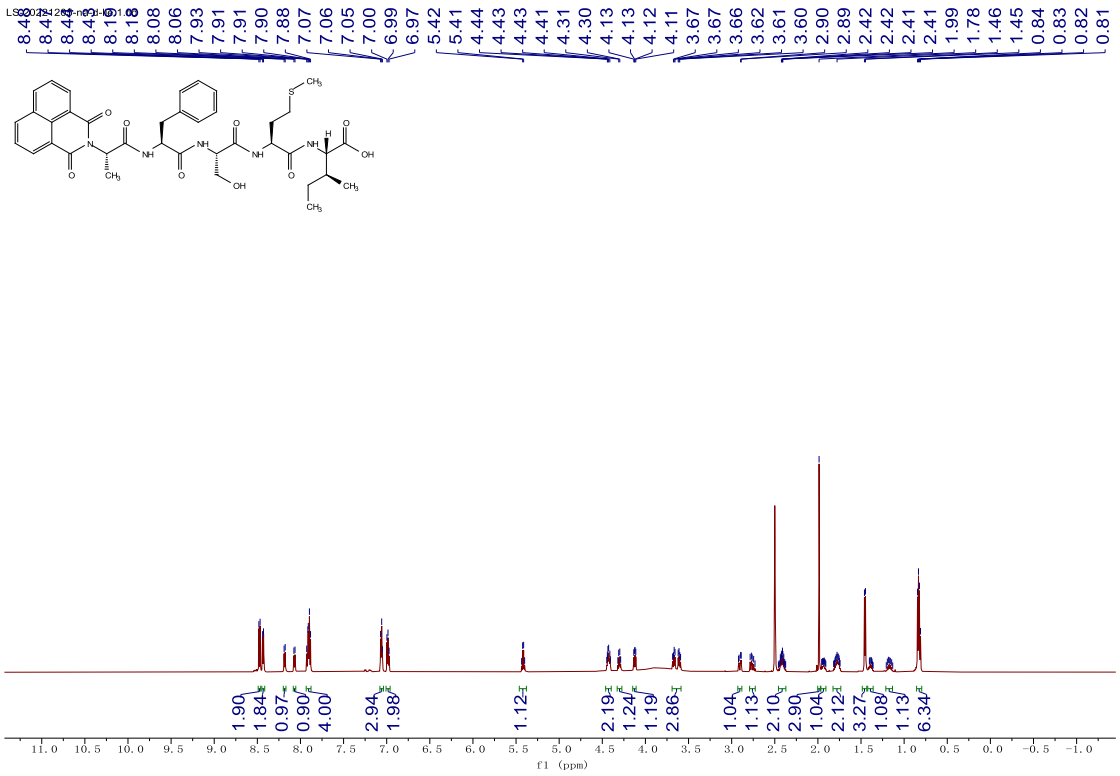
^{13}C NMR spectrum for compound **1y**



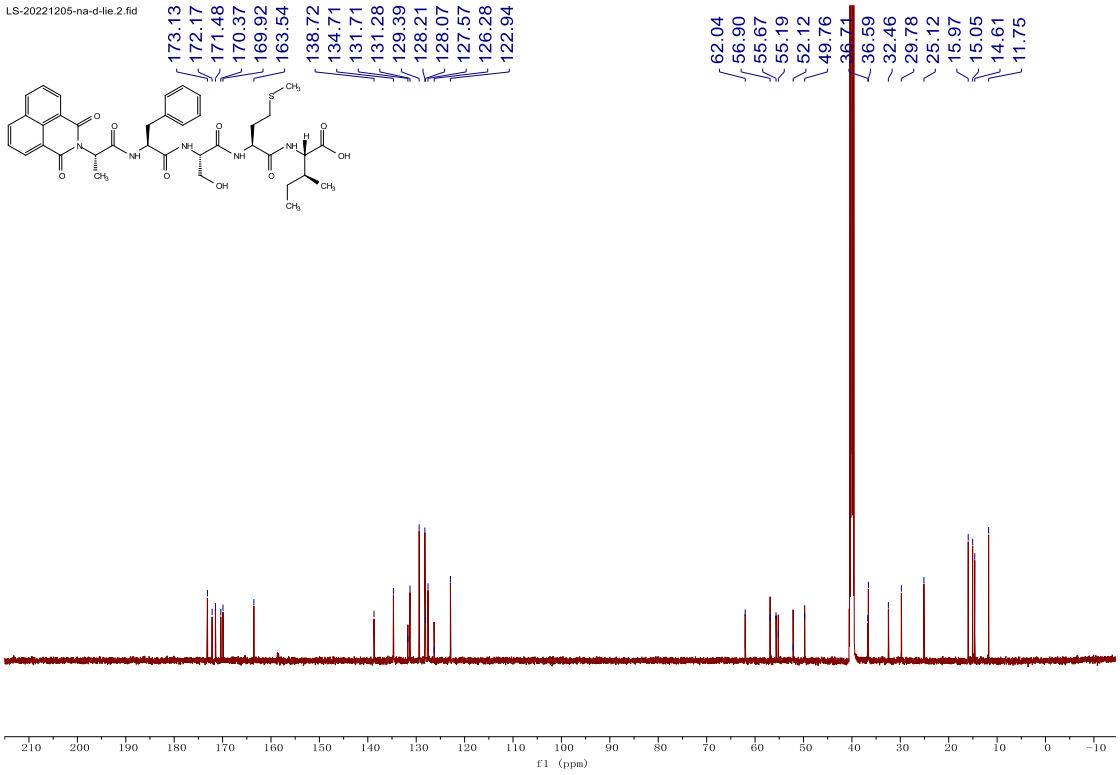
^{1}H NMR spectrum for compound **1z**



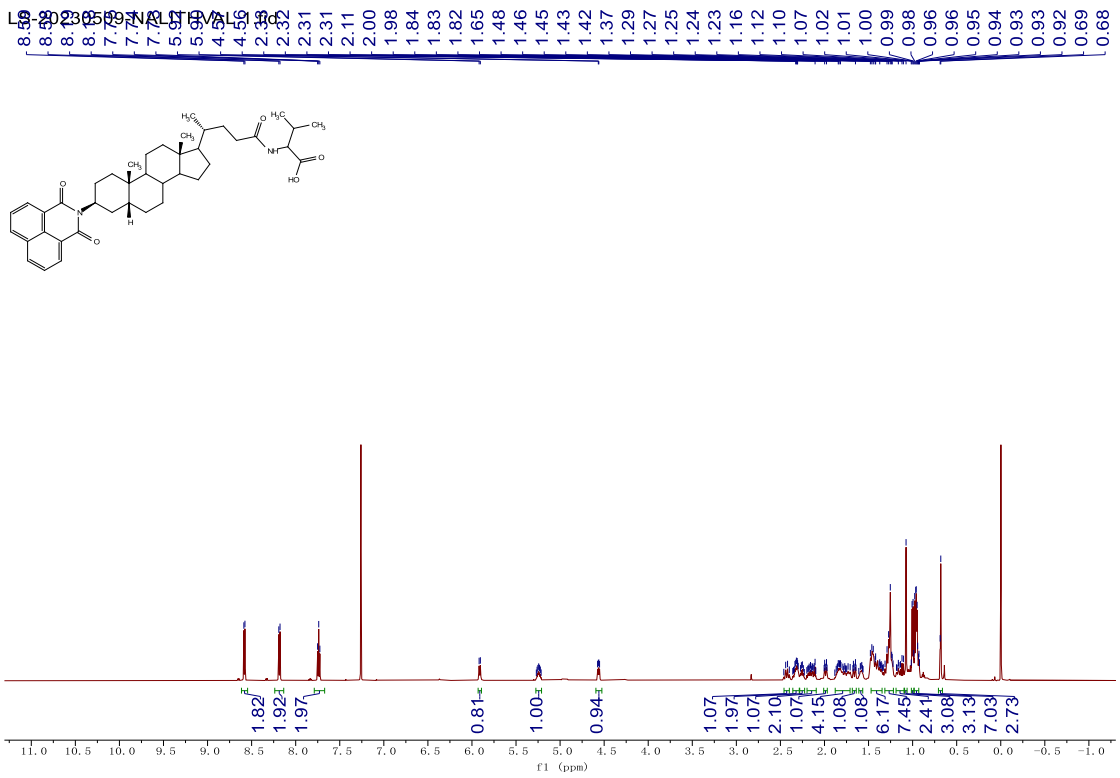
^{13}C NMR spectrum for compound **1z**



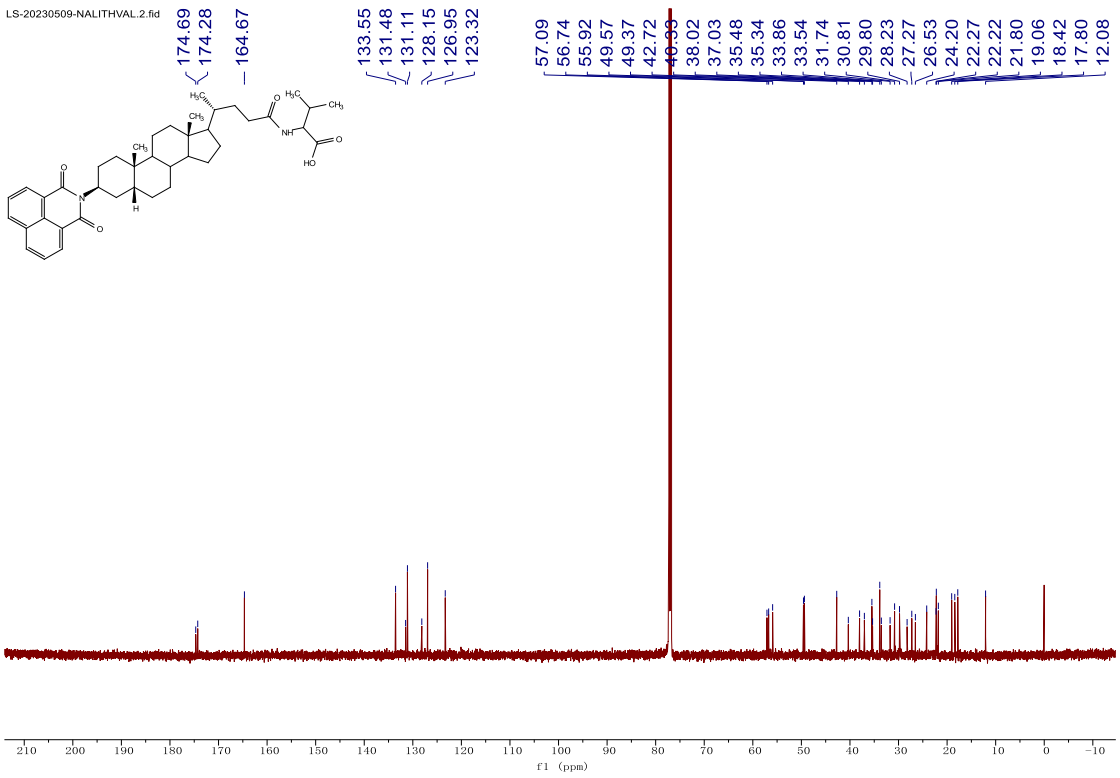
^{1}H NMR spectrum for compound **1aa**



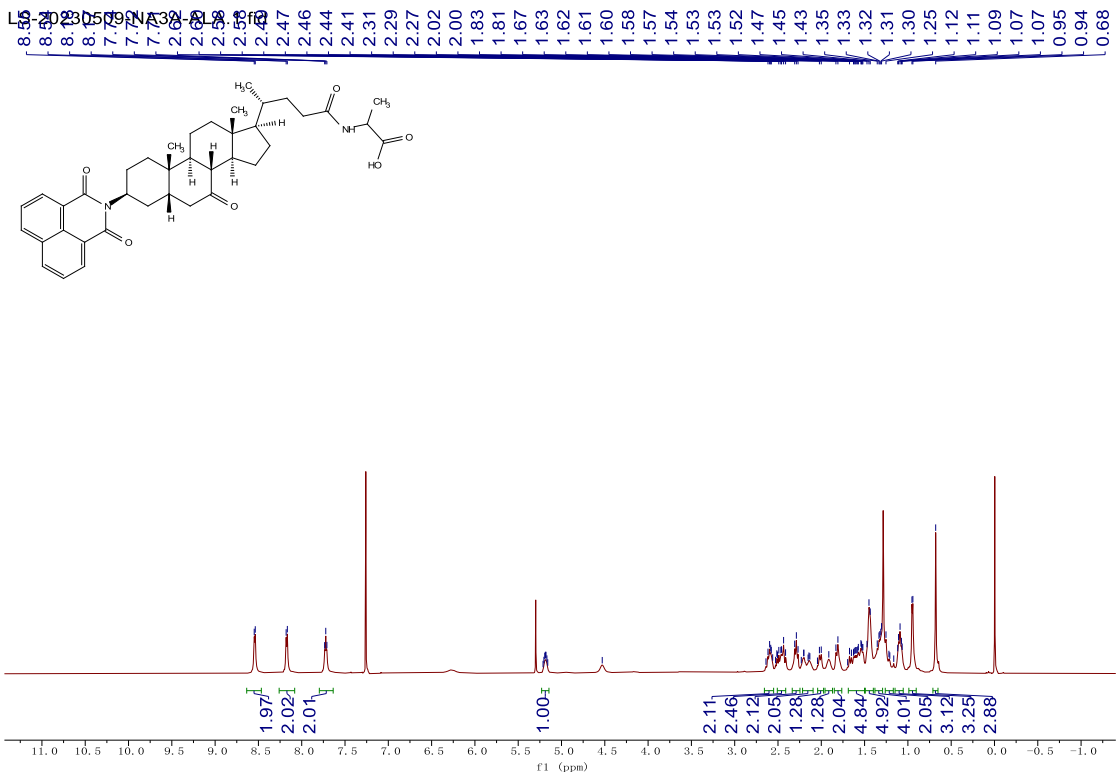
^{13}C NMR spectrum for compound **1aa**



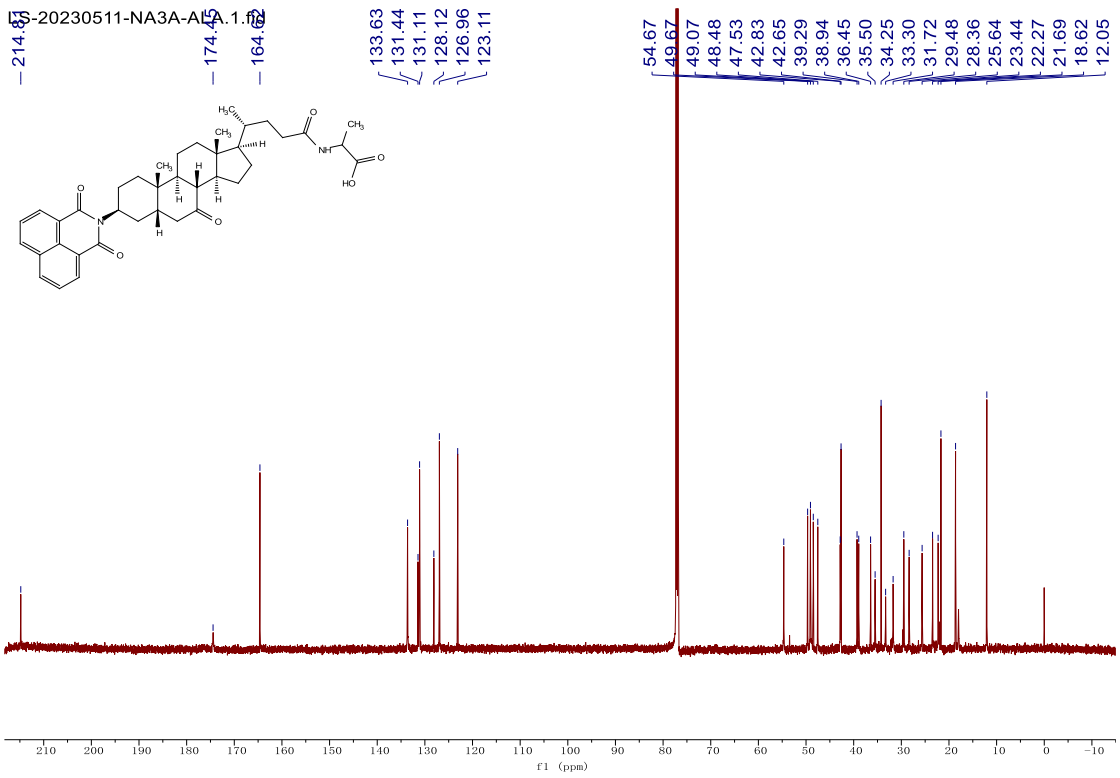
^{1}H NMR spectrum for compound **1bb**



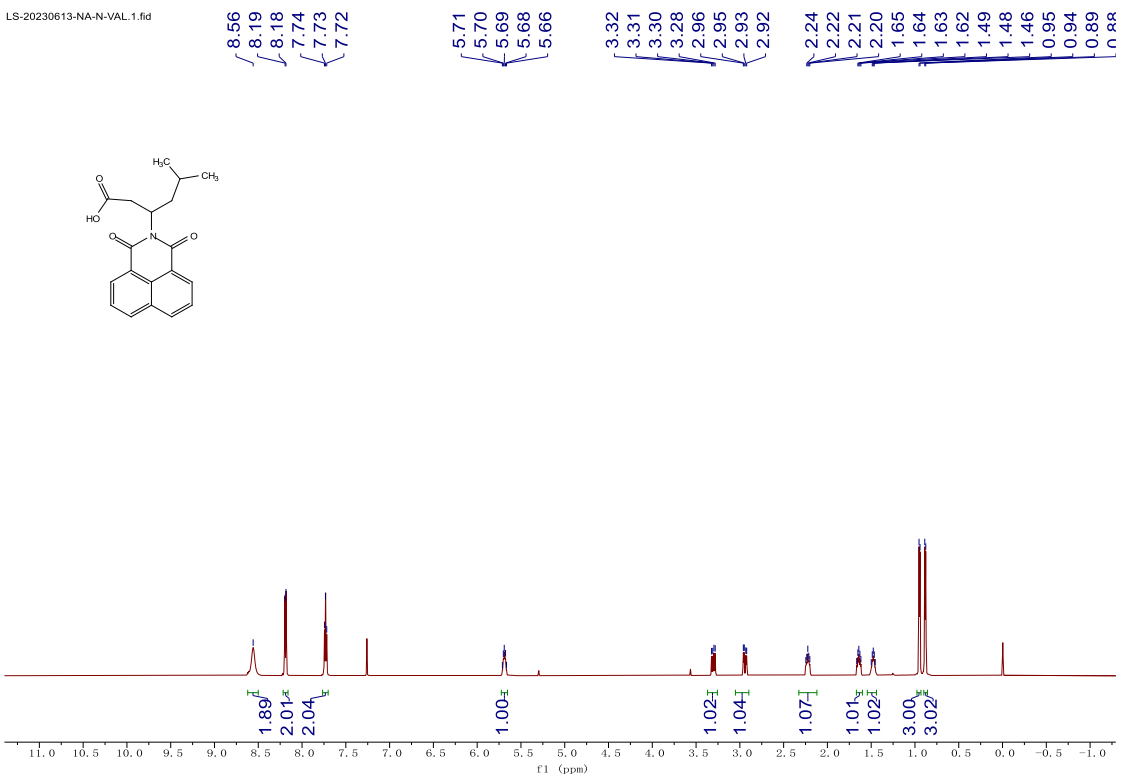
^{13}C NMR spectrum for compound **1bb**



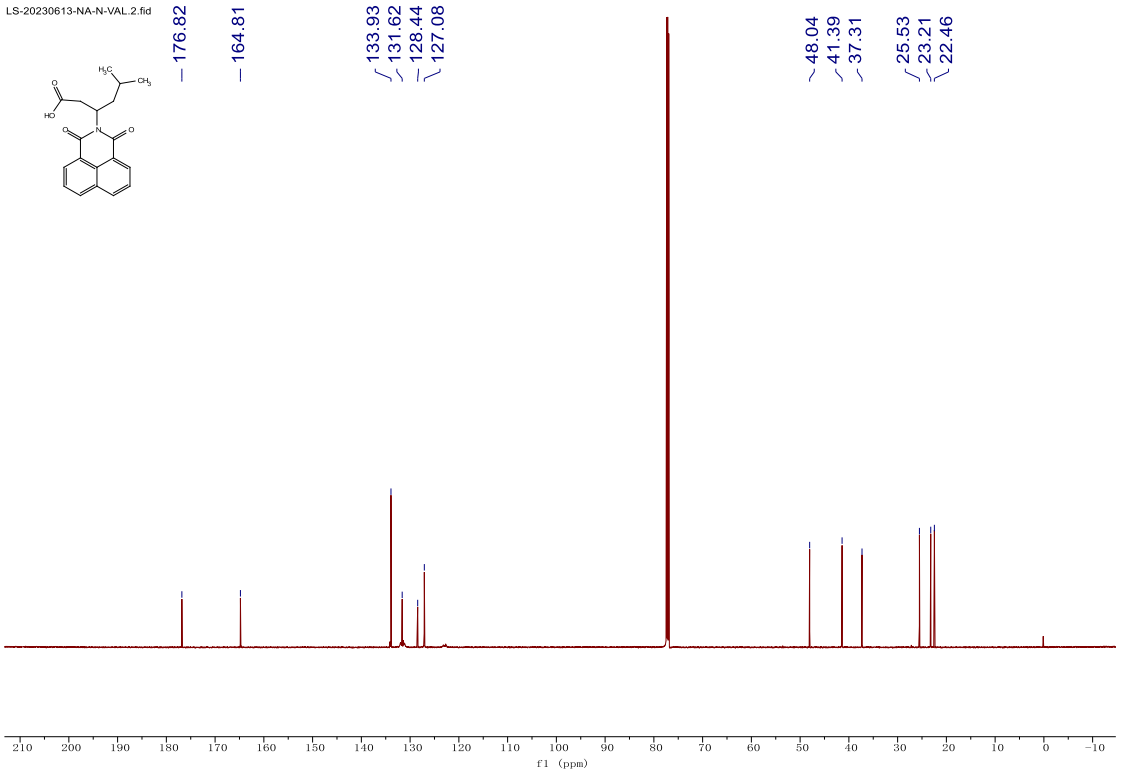
^{1}H NMR spectrum for compound **1cc**



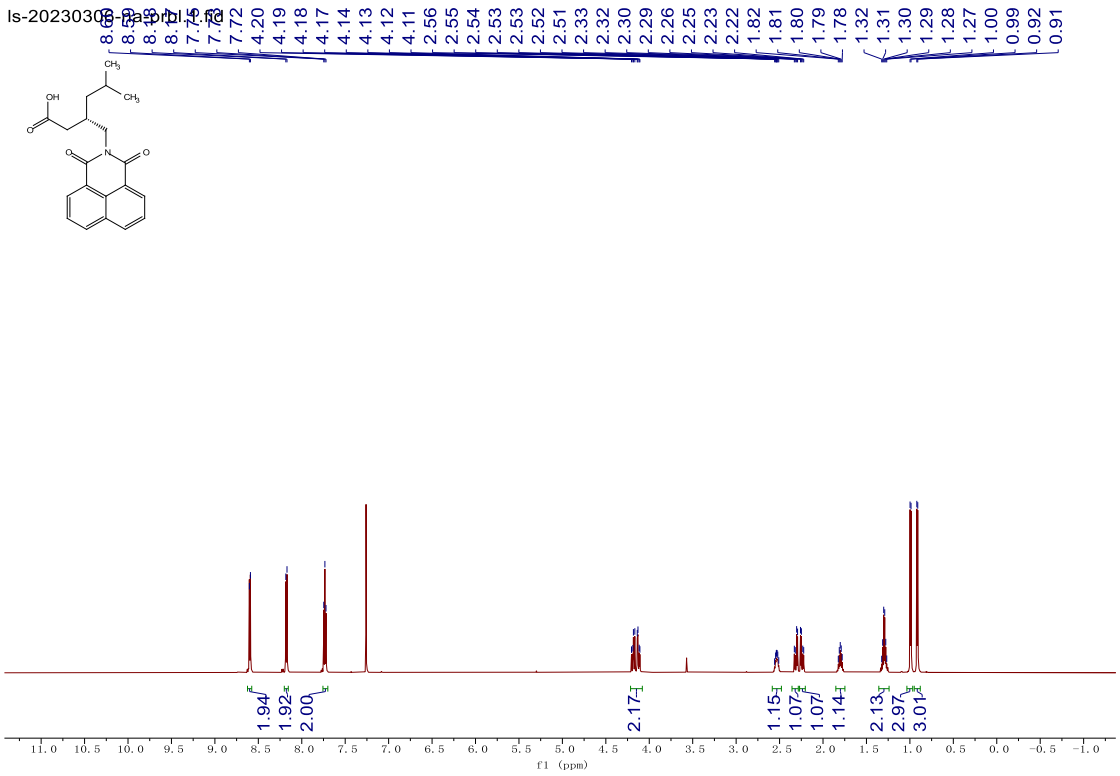
^{13}C NMR spectrum for compound **1cc**



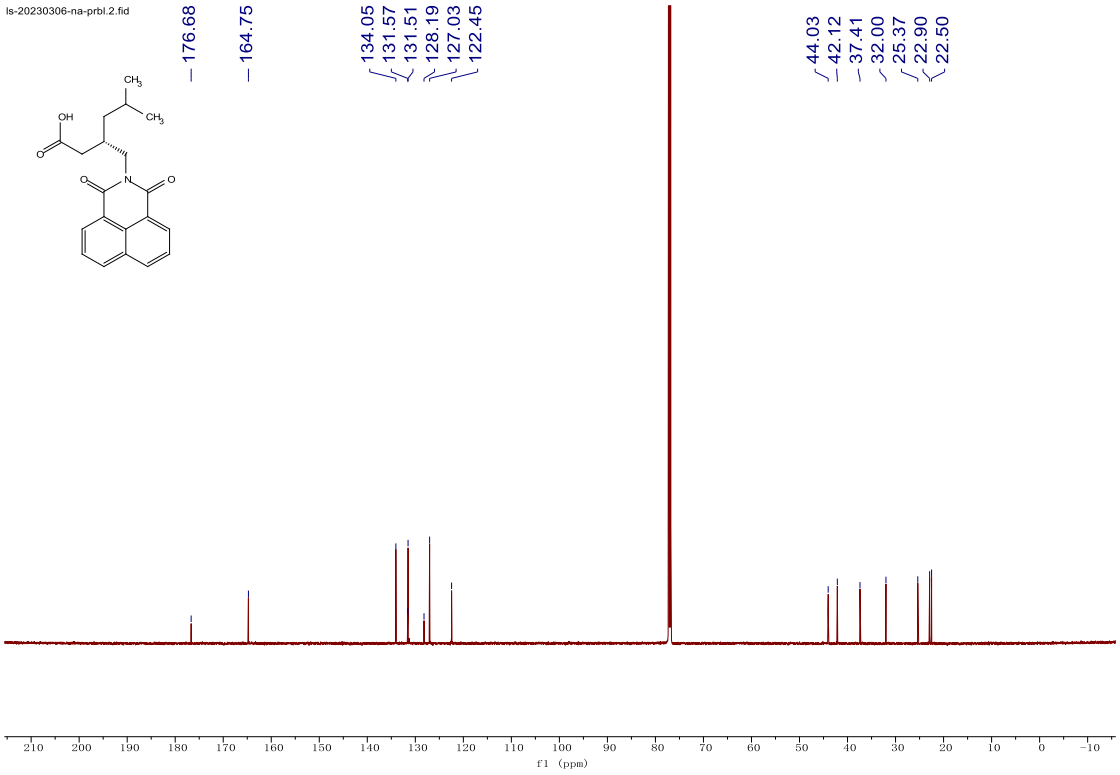
^{1}H NMR spectrum for compound **3a**



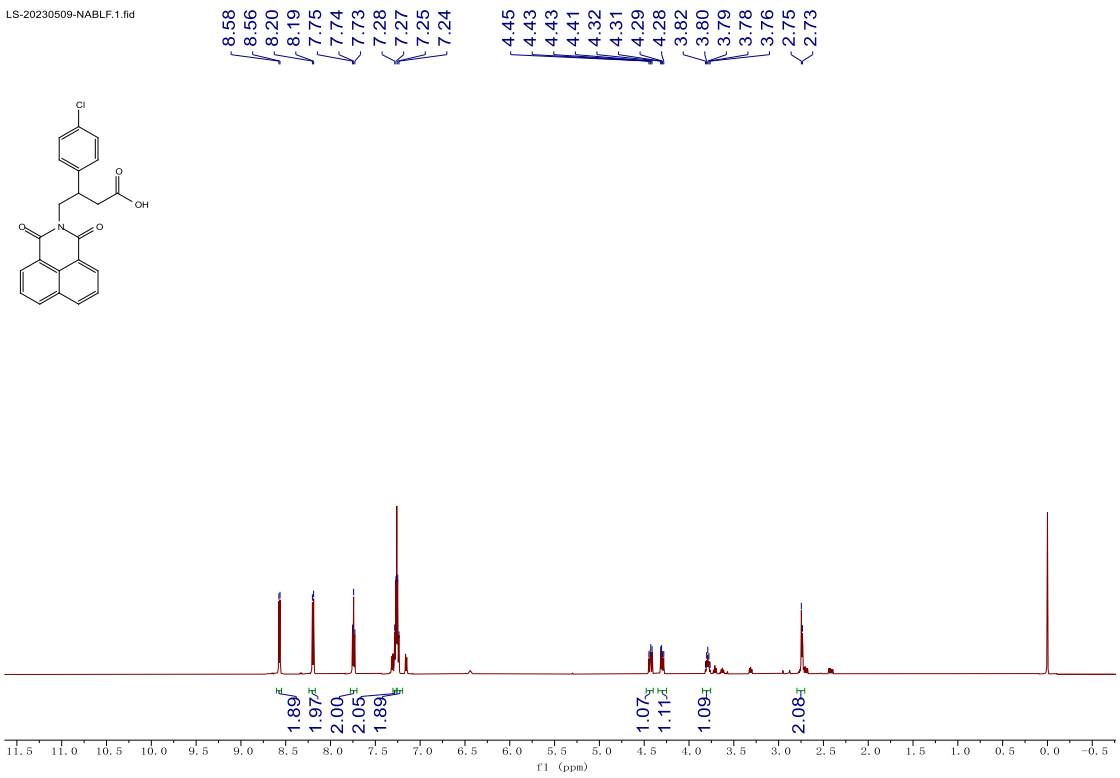
^{13}C NMR spectrum for compound **3a**



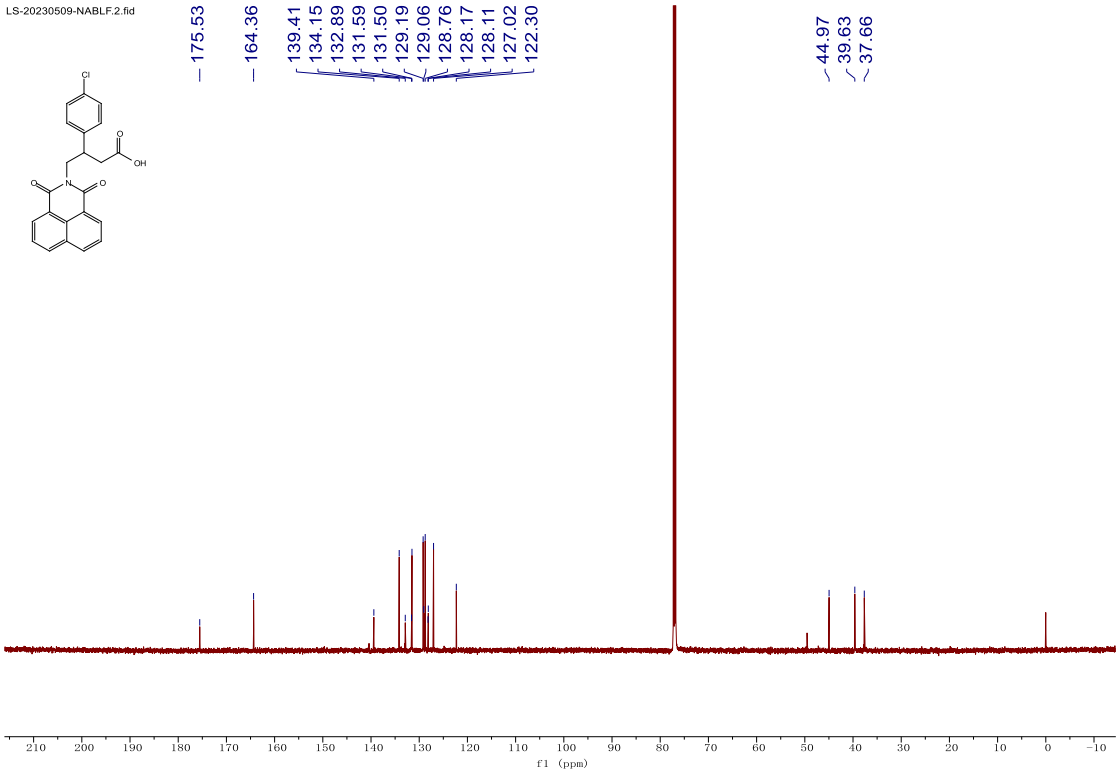
^{1}H NMR spectrum for compound **3d**



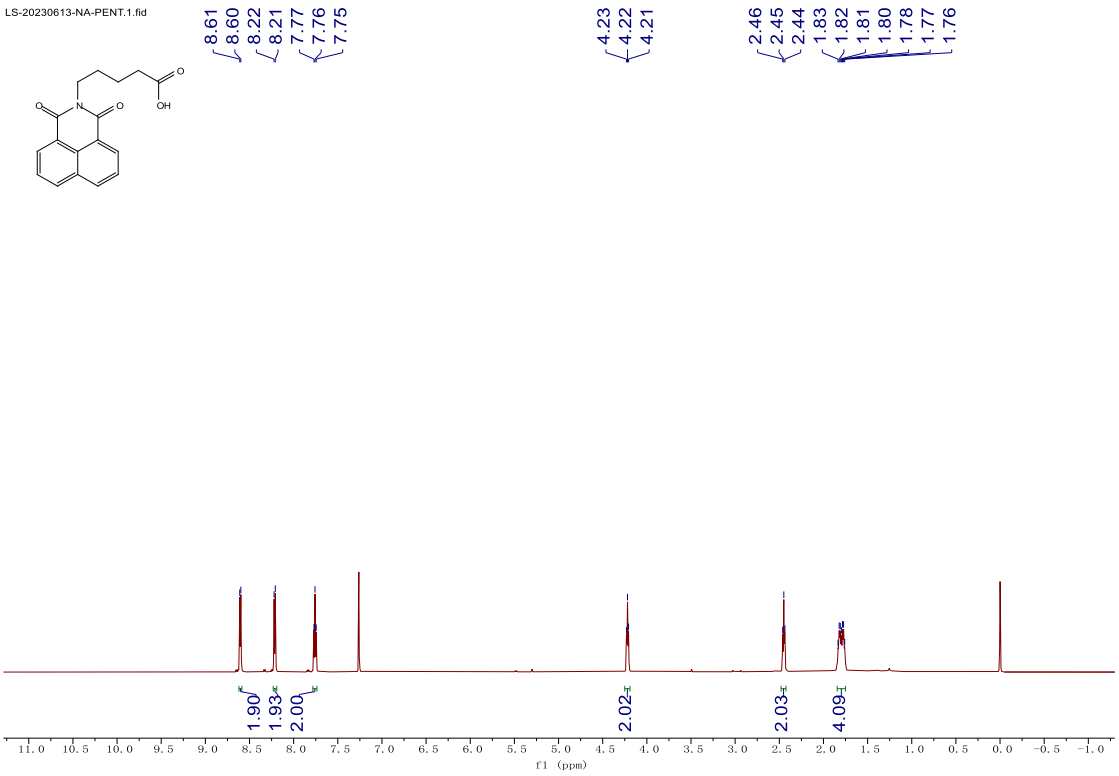
^{13}C NMR spectrum for compound **3d**



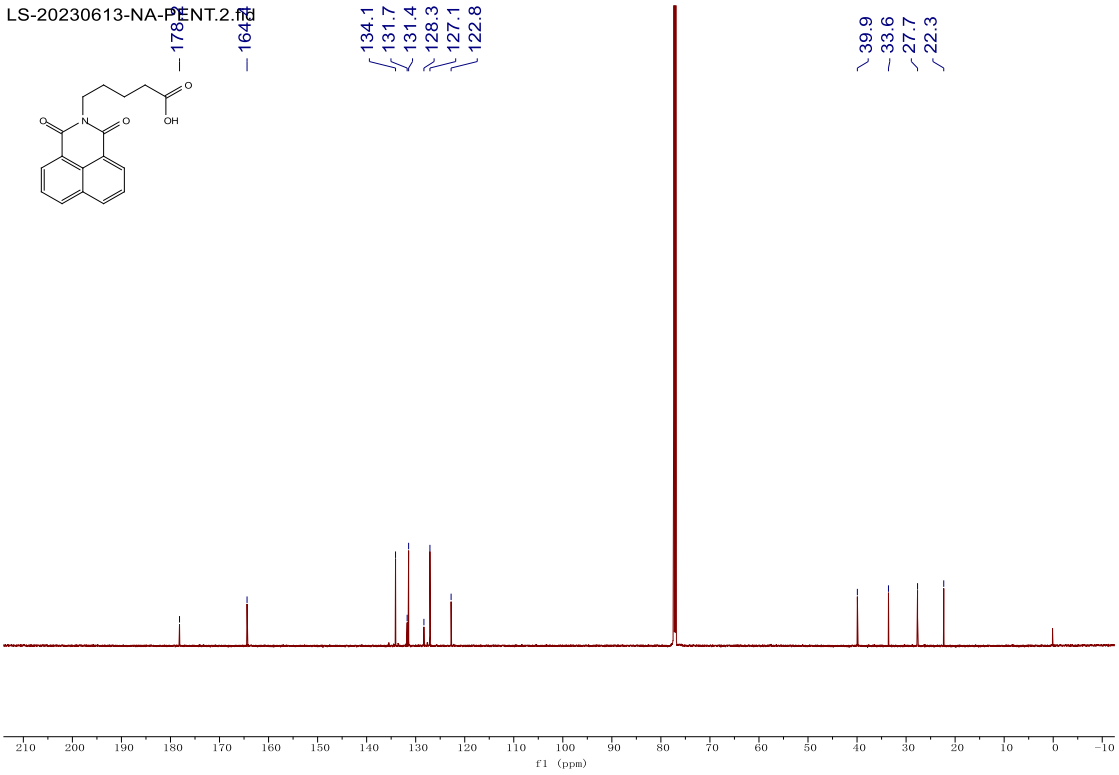
^{1}H NMR spectrum for compound **3e**



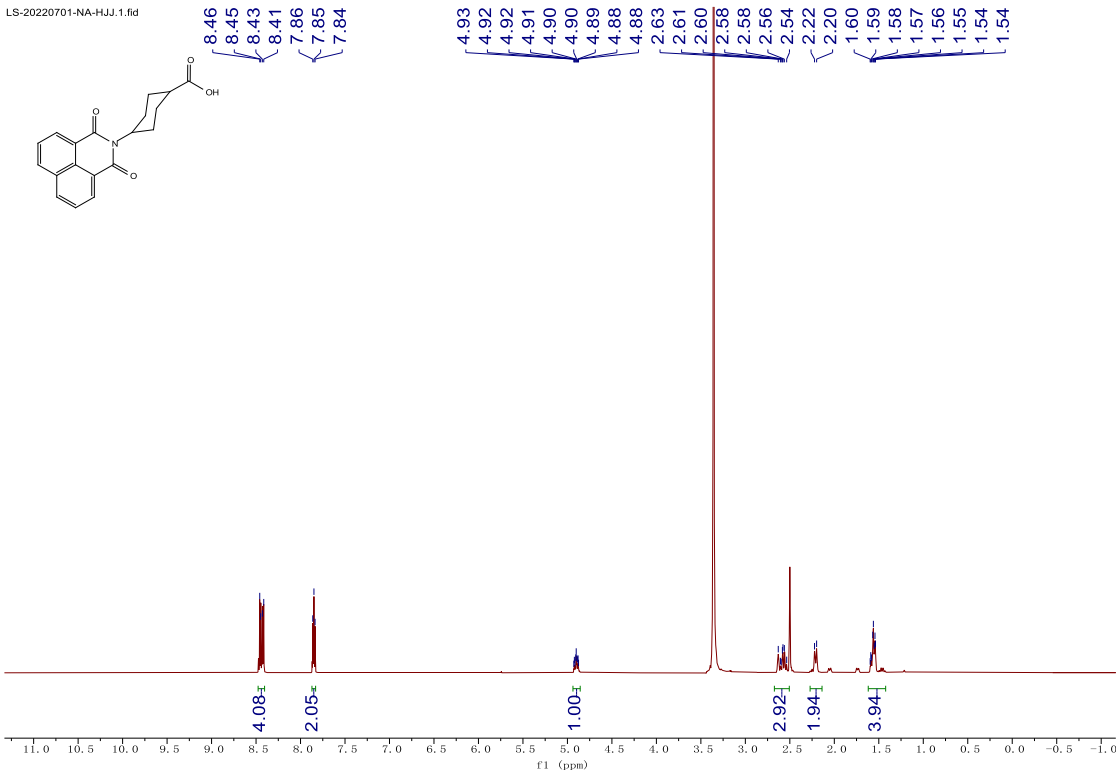
^{13}C NMR spectrum for compound **3e**



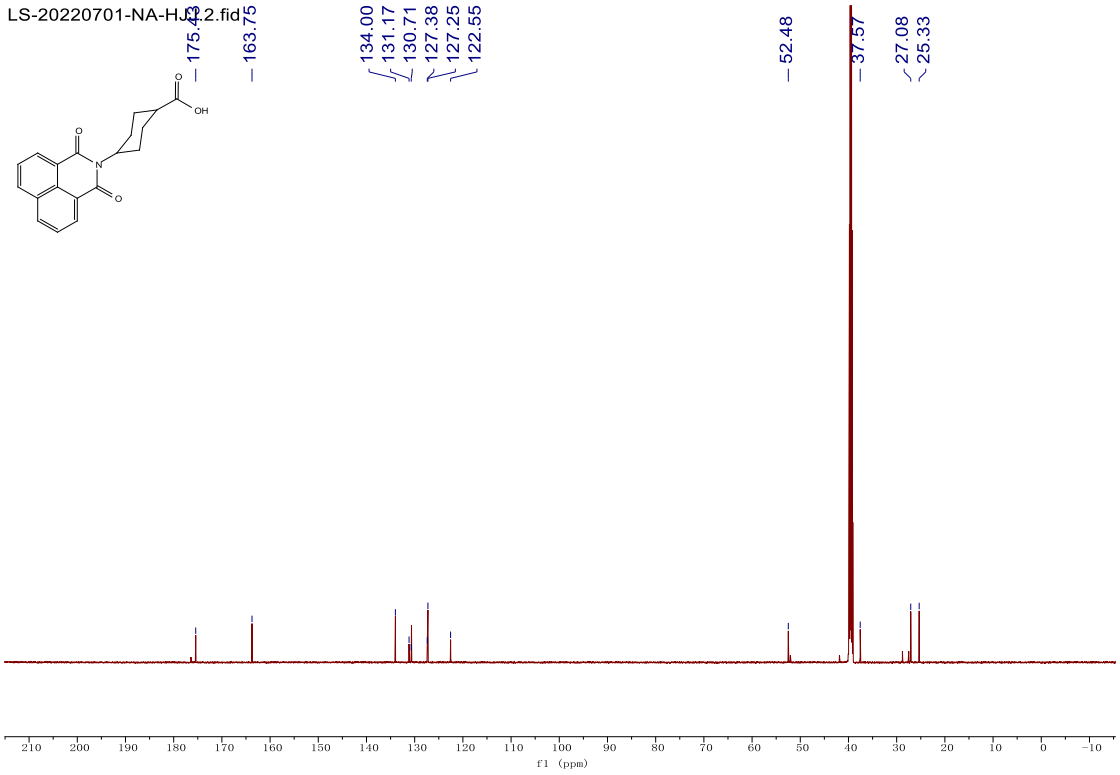
^{1}H NMR spectrum for compound **3f**



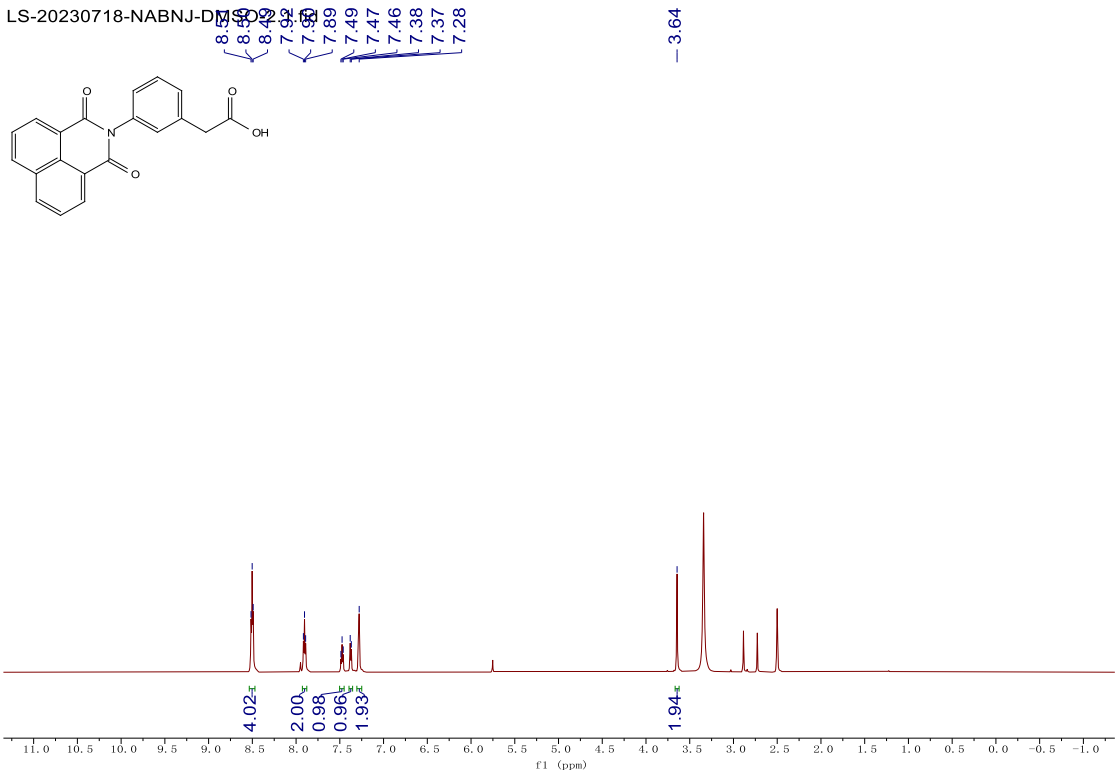
^{13}C NMR spectrum for compound **3f**



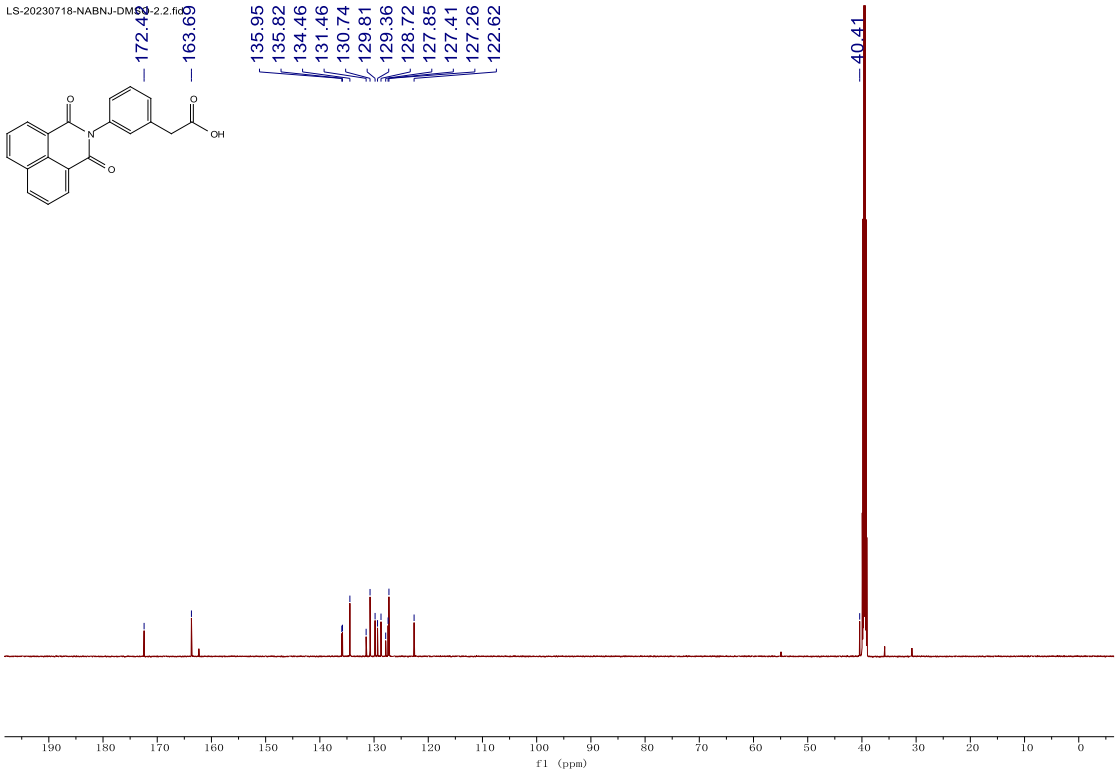
^{1}H NMR spectrum for compound **3g**



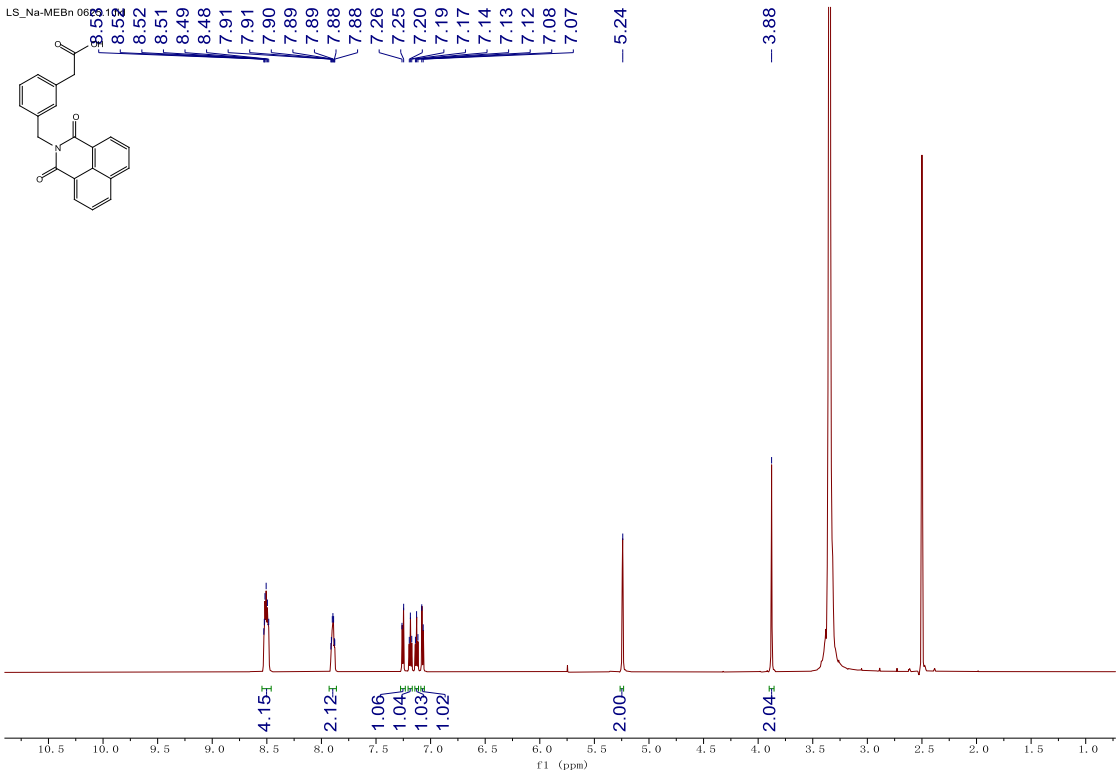
^{13}C NMR spectrum for compound **3g**



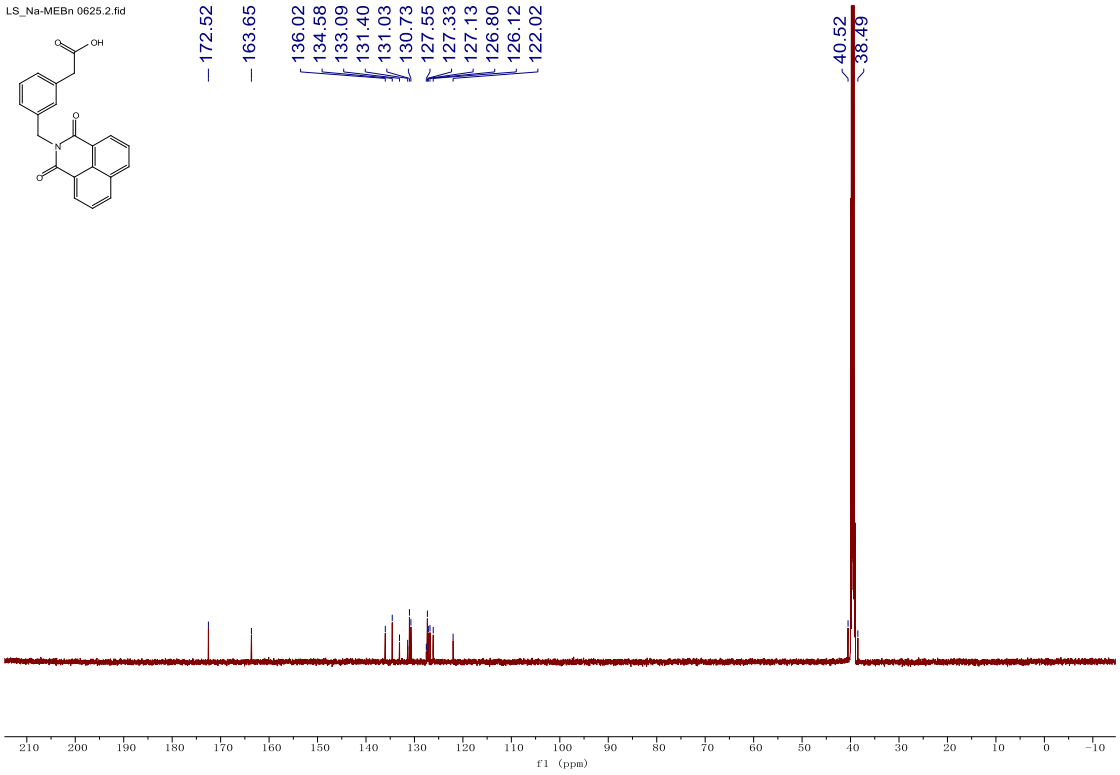
^{1}H NMR spectrum for compound **3h**



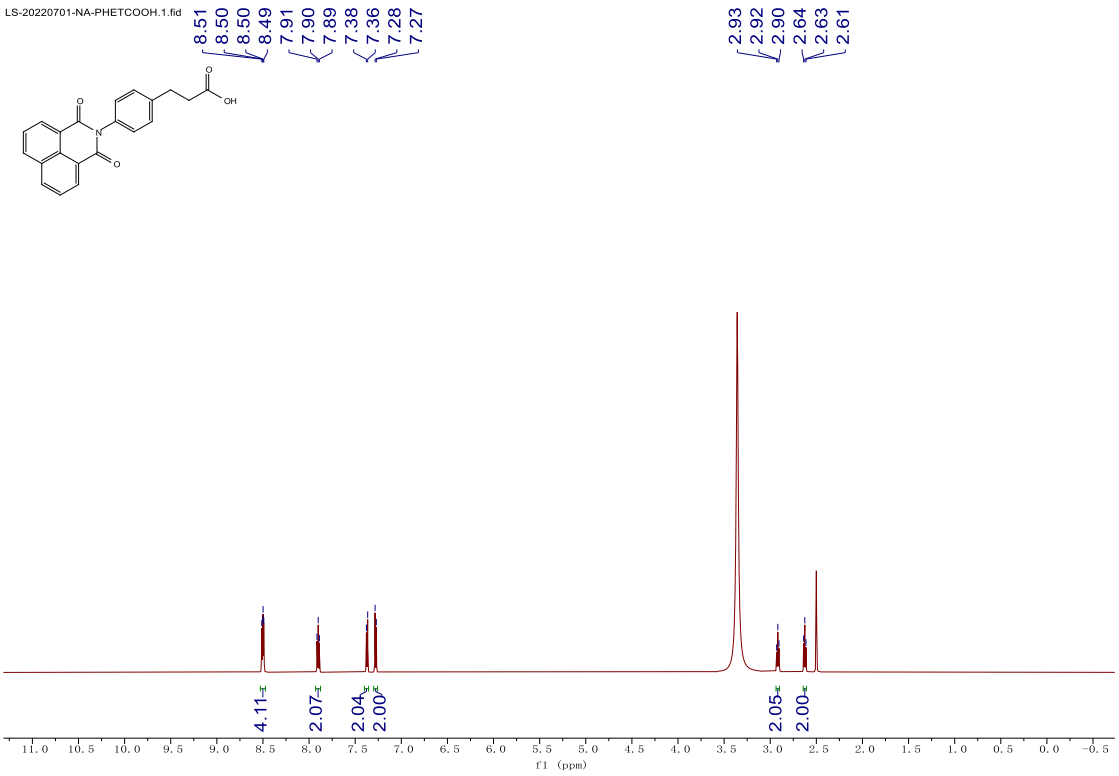
^{13}C NMR spectrum for compound **3h**



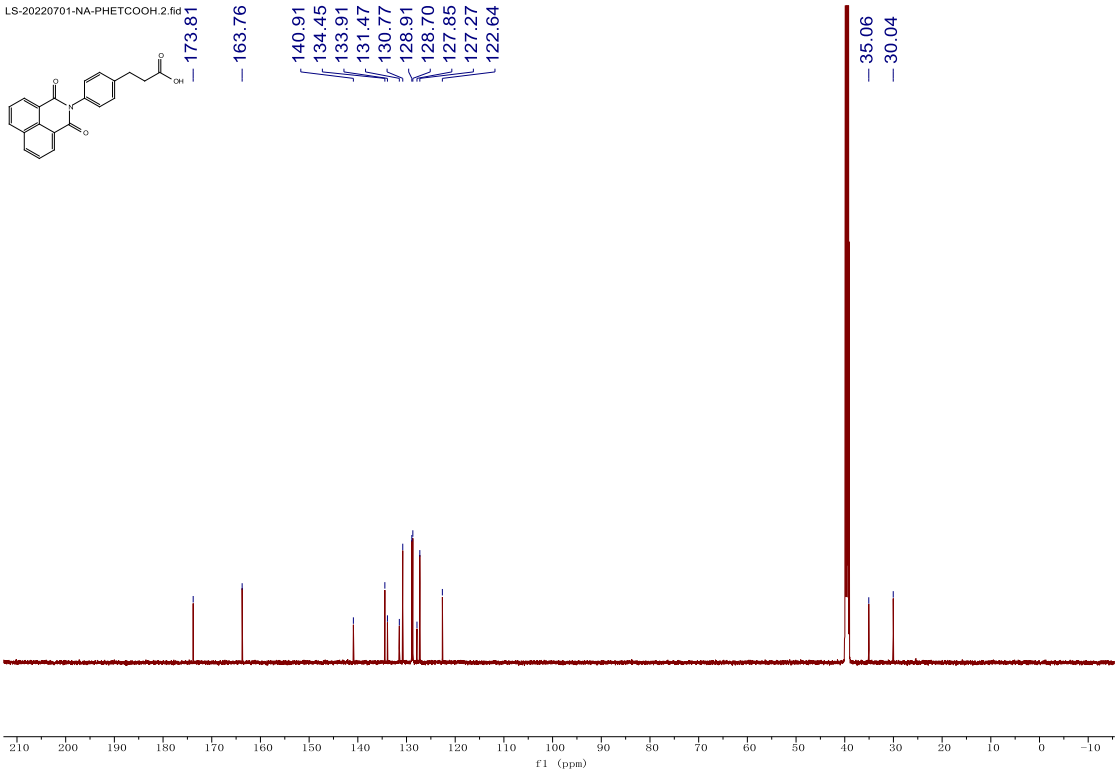
^{1}H NMR spectrum for compound **3i**



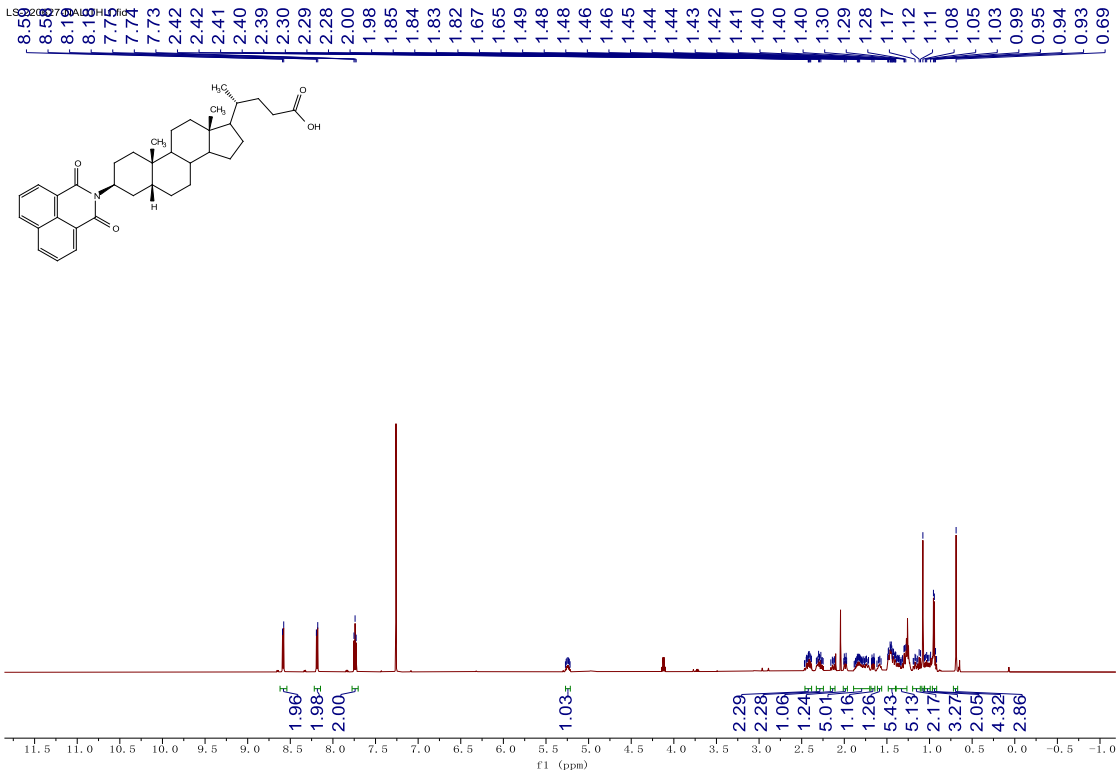
^{13}C NMR spectrum for compound **3i**



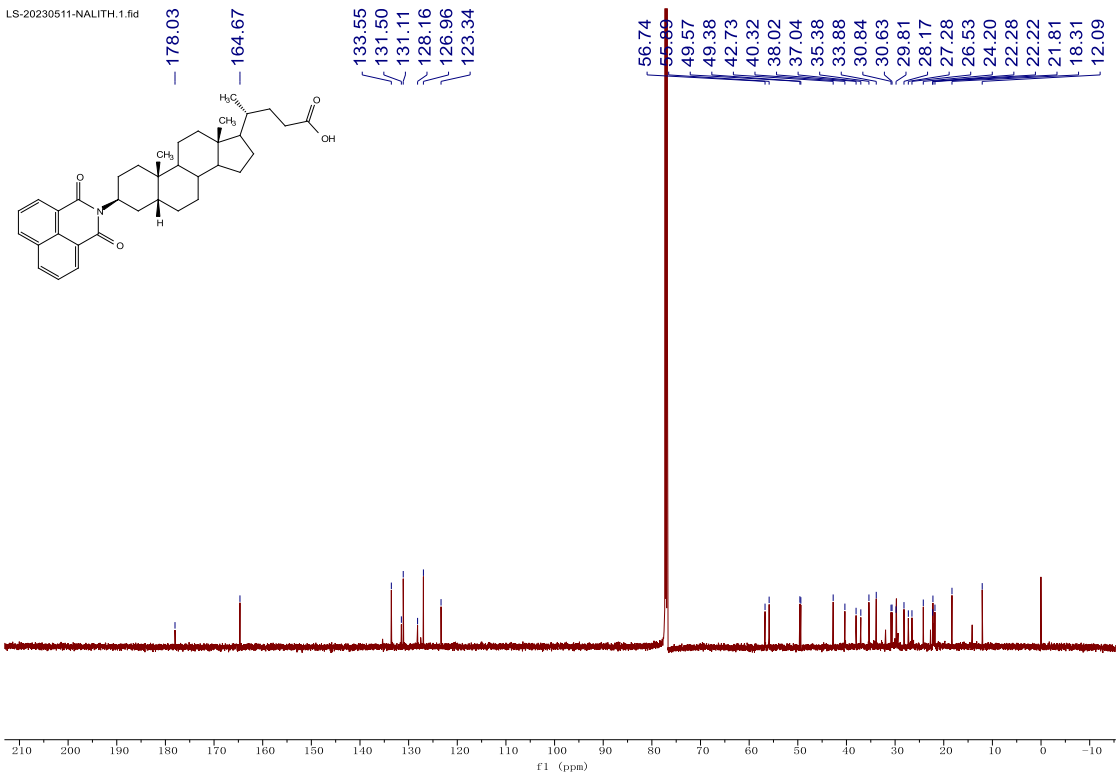
^{1}H NMR spectrum for compound 3j



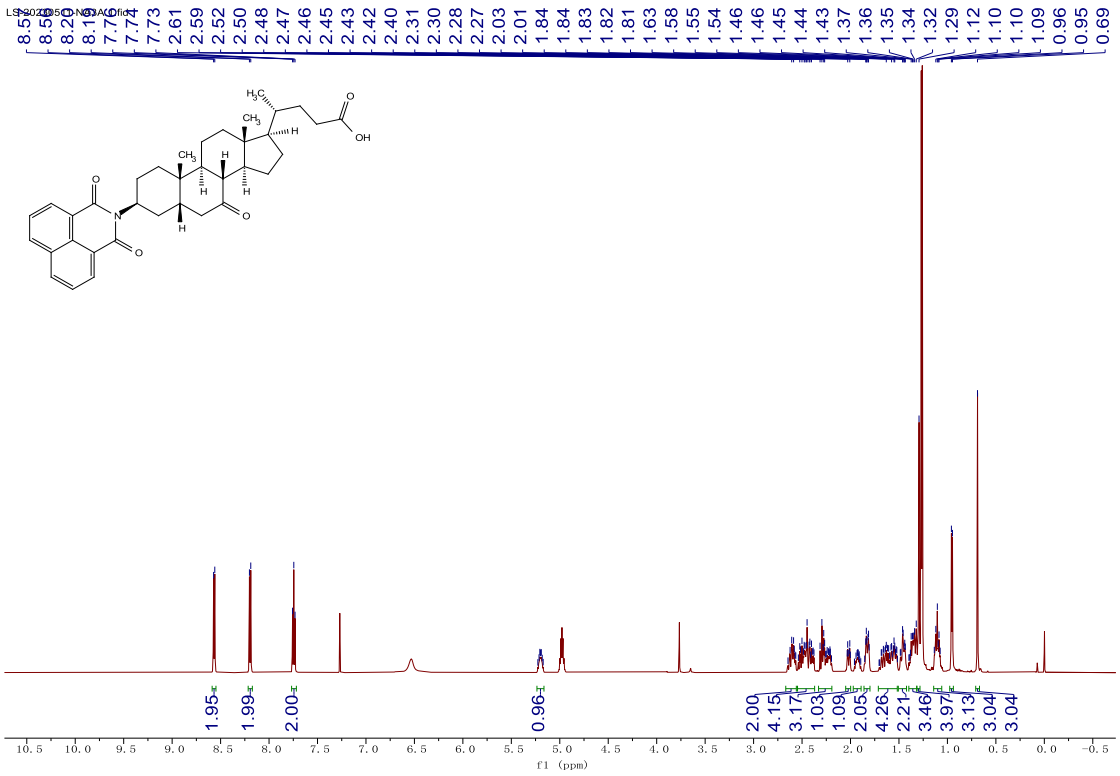
^{13}C NMR spectrum for compound **3j**



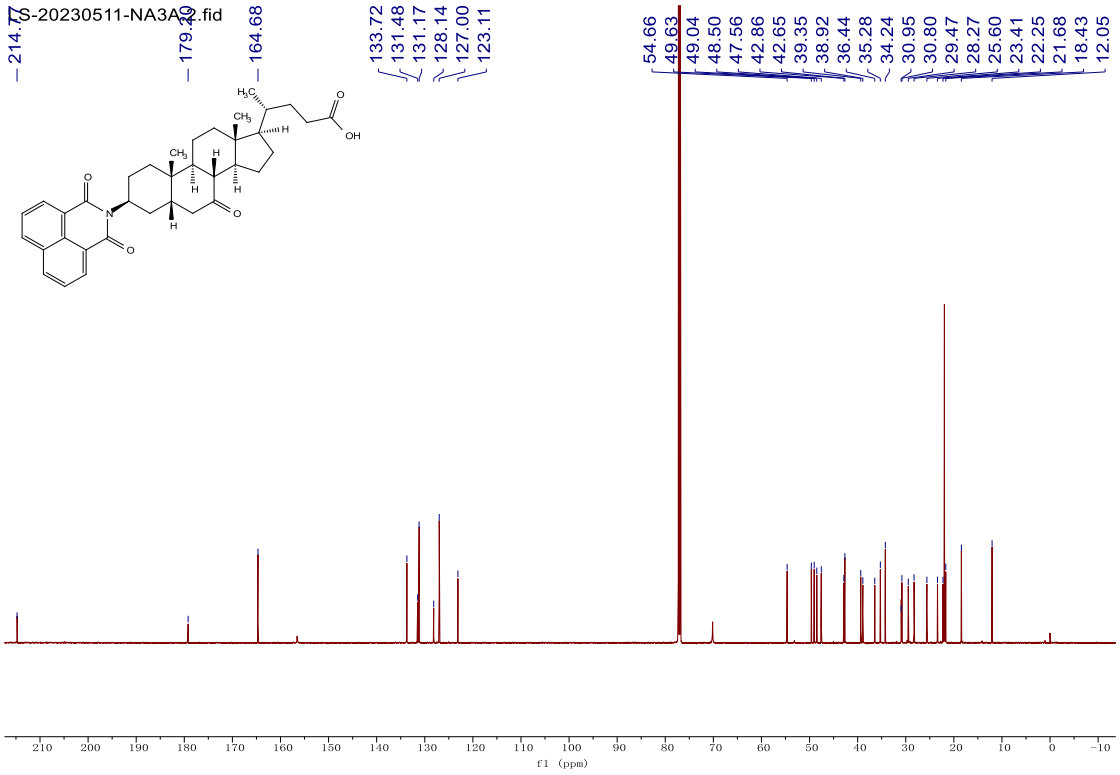
^{1}H NMR spectrum for compound **3k**



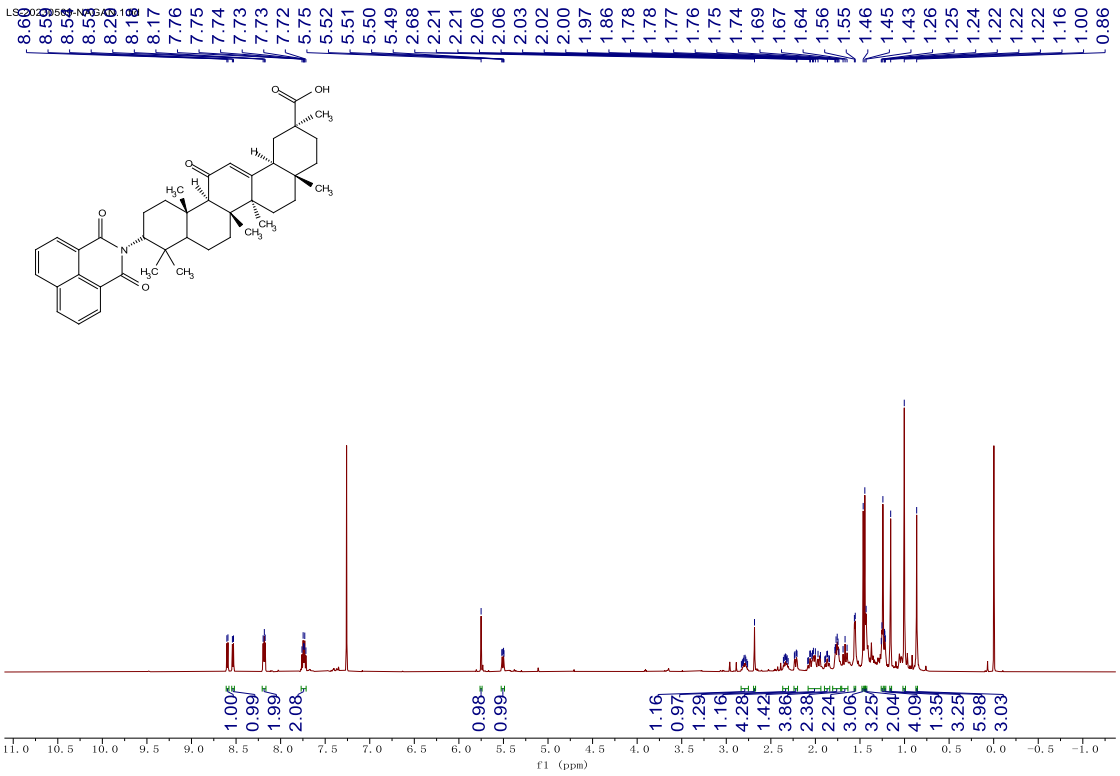
^{13}C NMR spectrum for compound **3k**



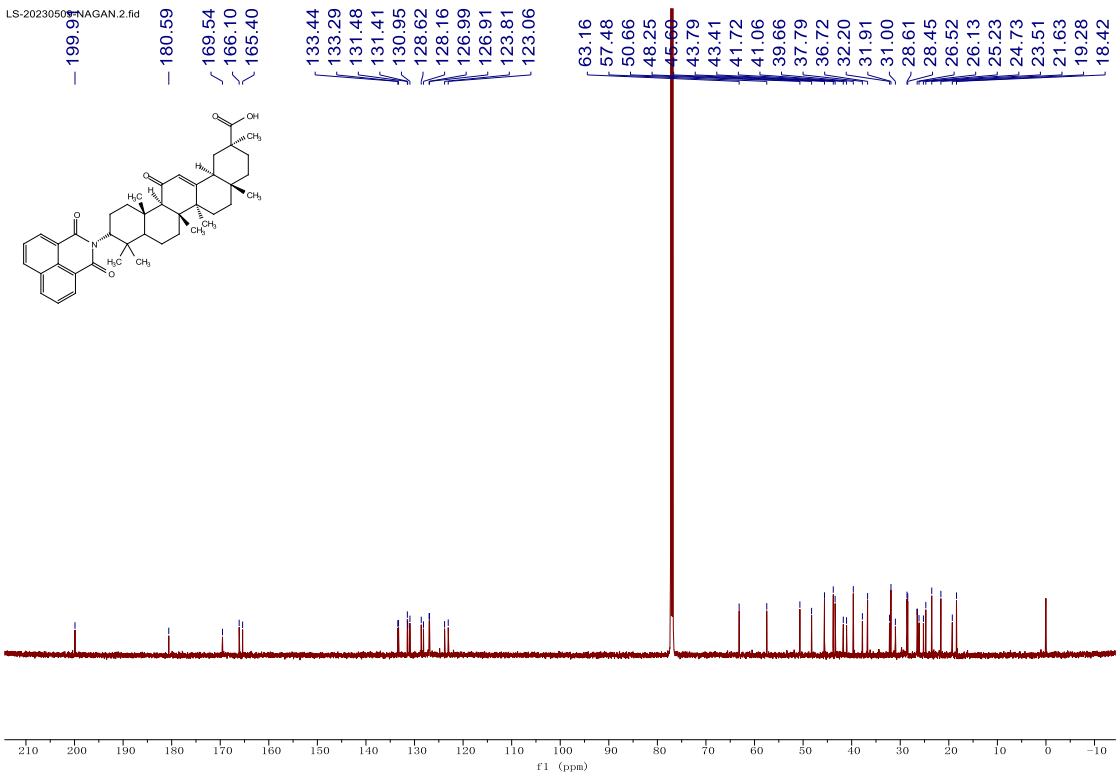
^{1}H NMR spectrum for compound **3l**



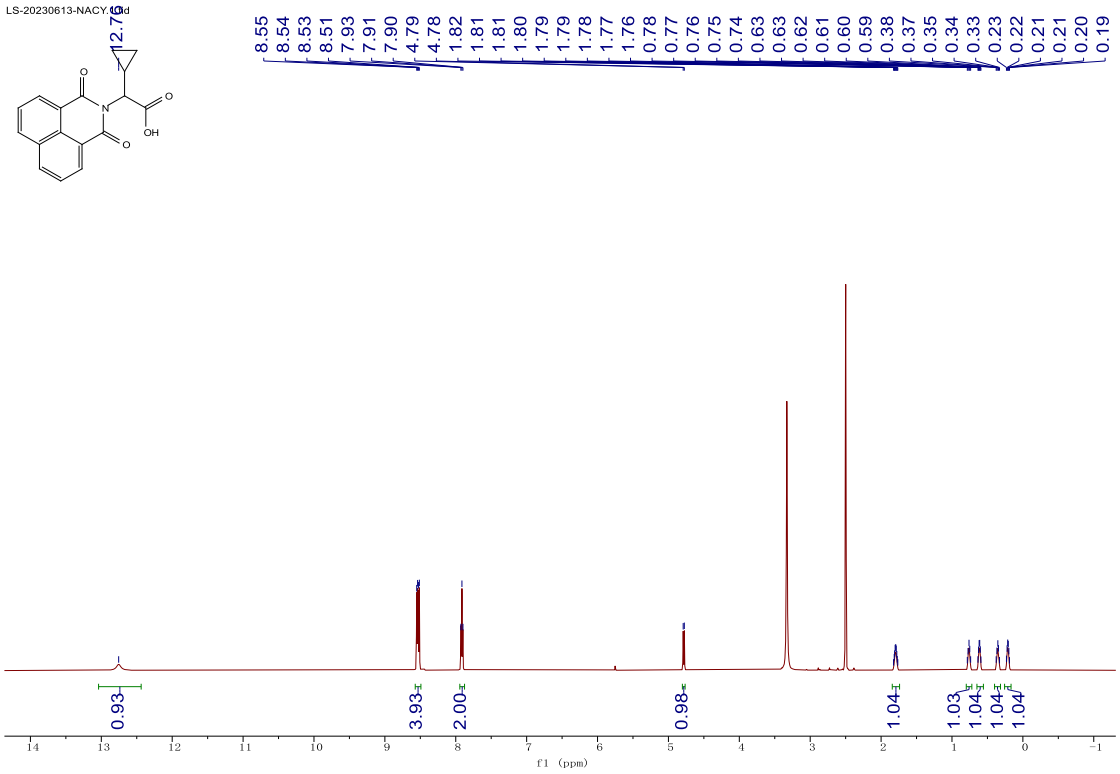
^{13}C NMR spectrum for compound **3l**



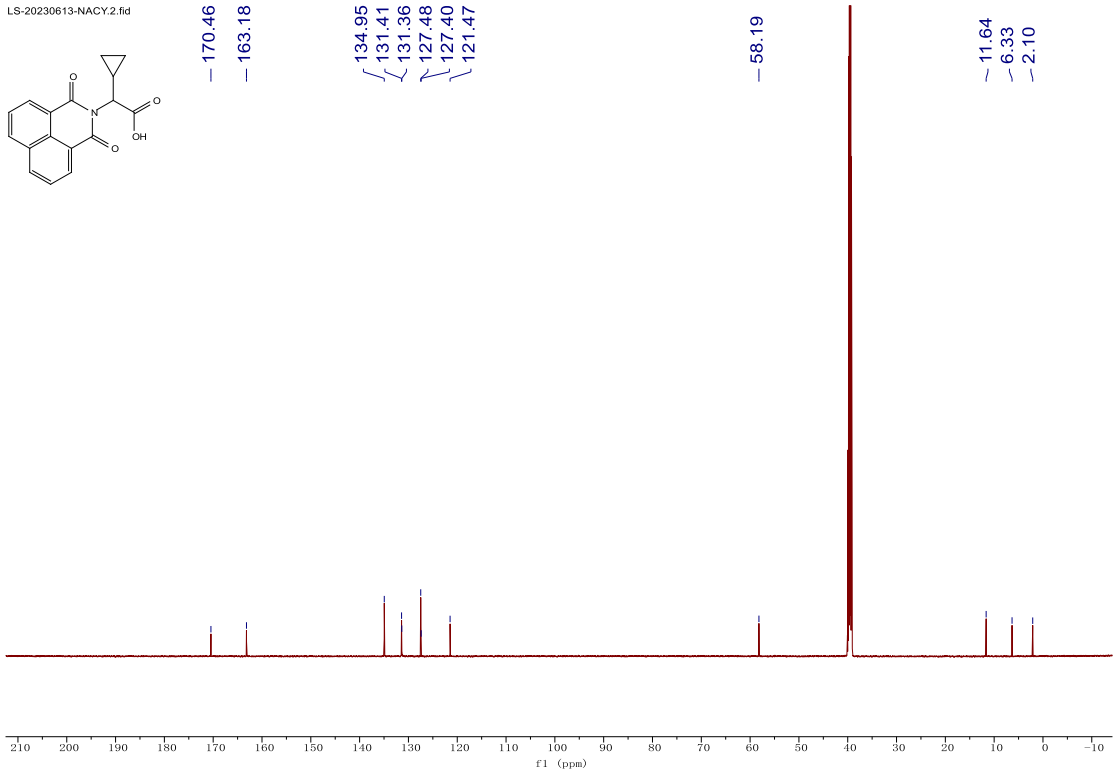
^{1}H NMR spectrum for compound **3m**



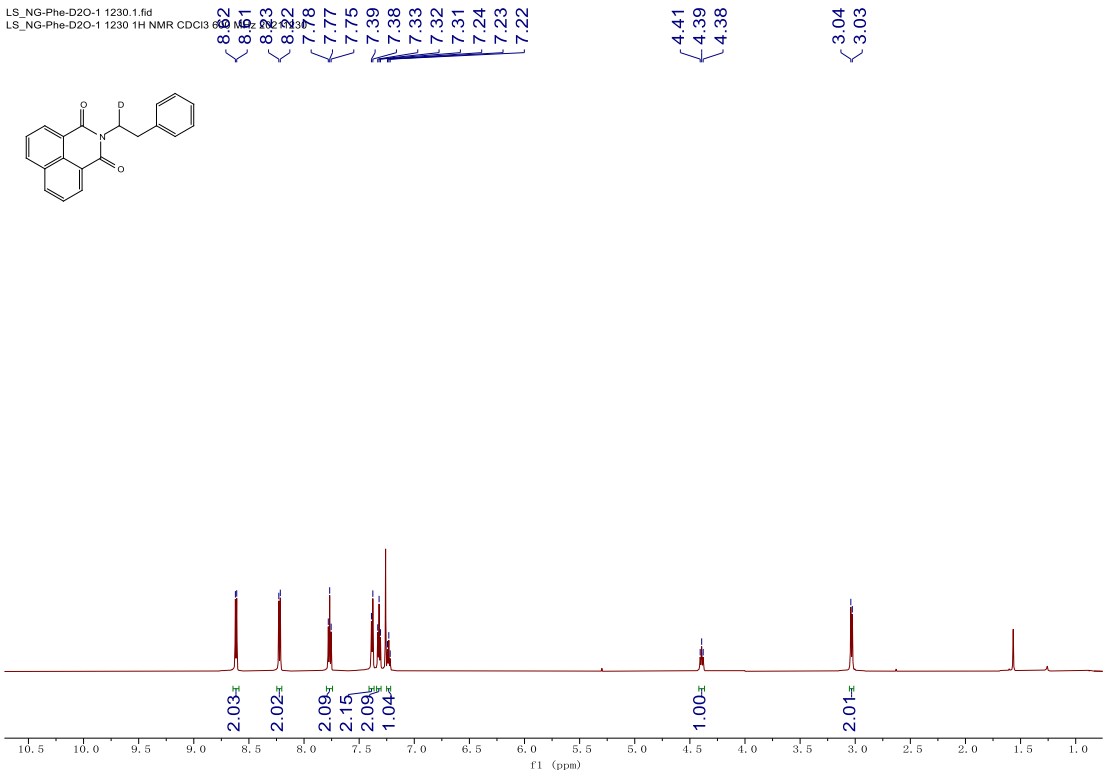
^{13}C NMR spectrum for compound **3m**



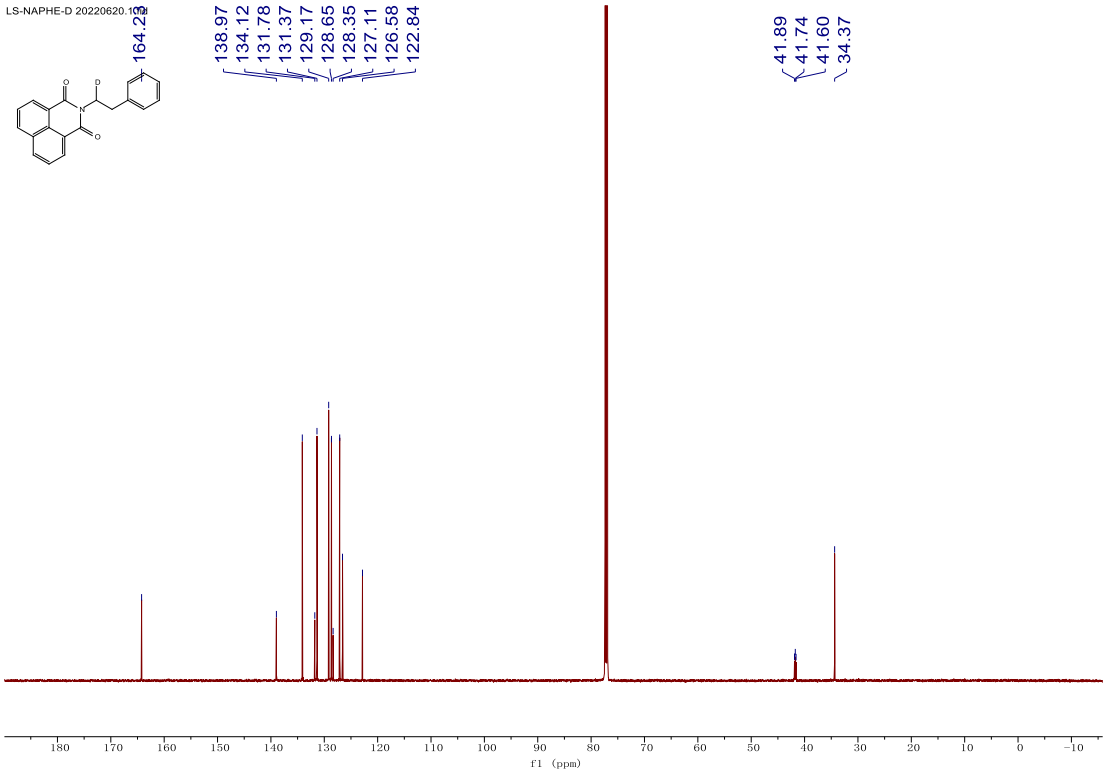
^{1}H NMR spectrum for compound **1ff**



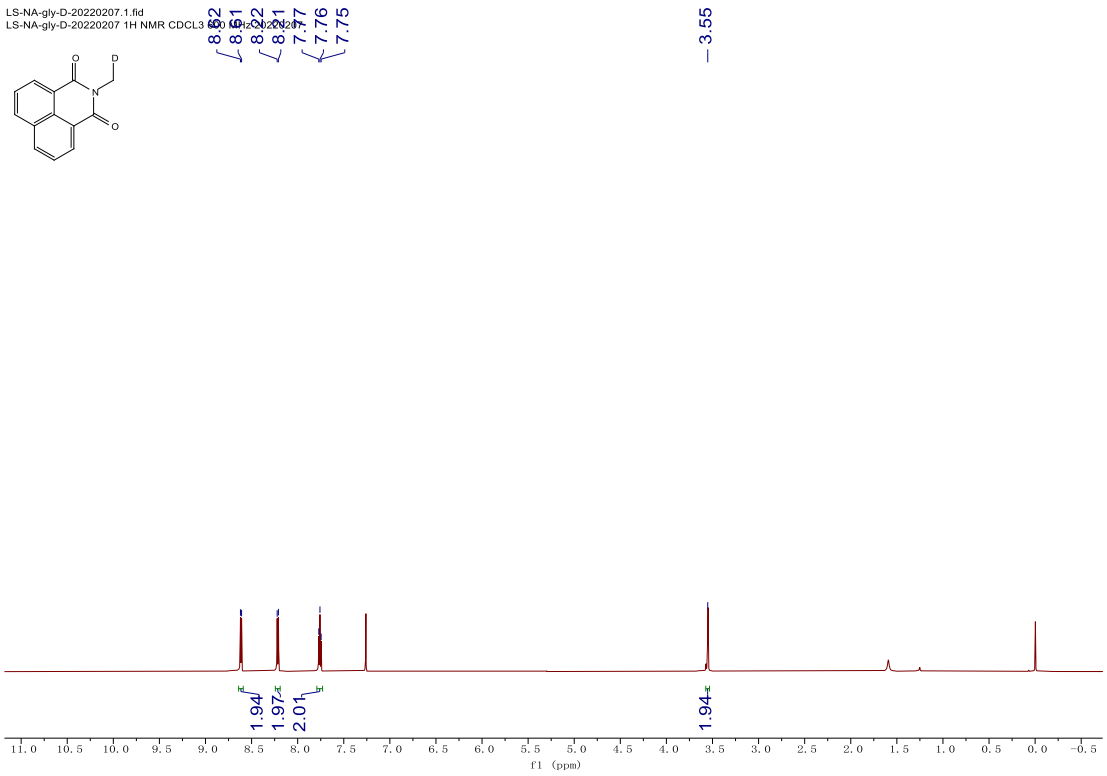
^{13}C NMR spectrum for compound **1ff**



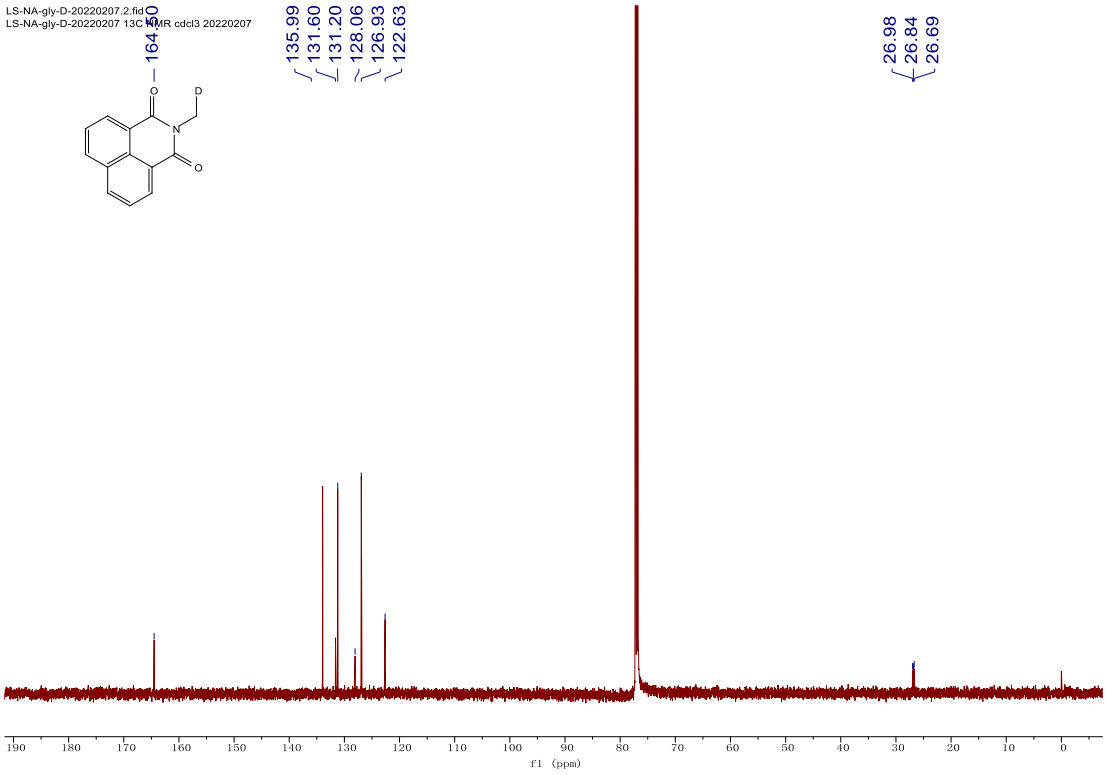
^{1}H NMR spectrum for compound **2a**



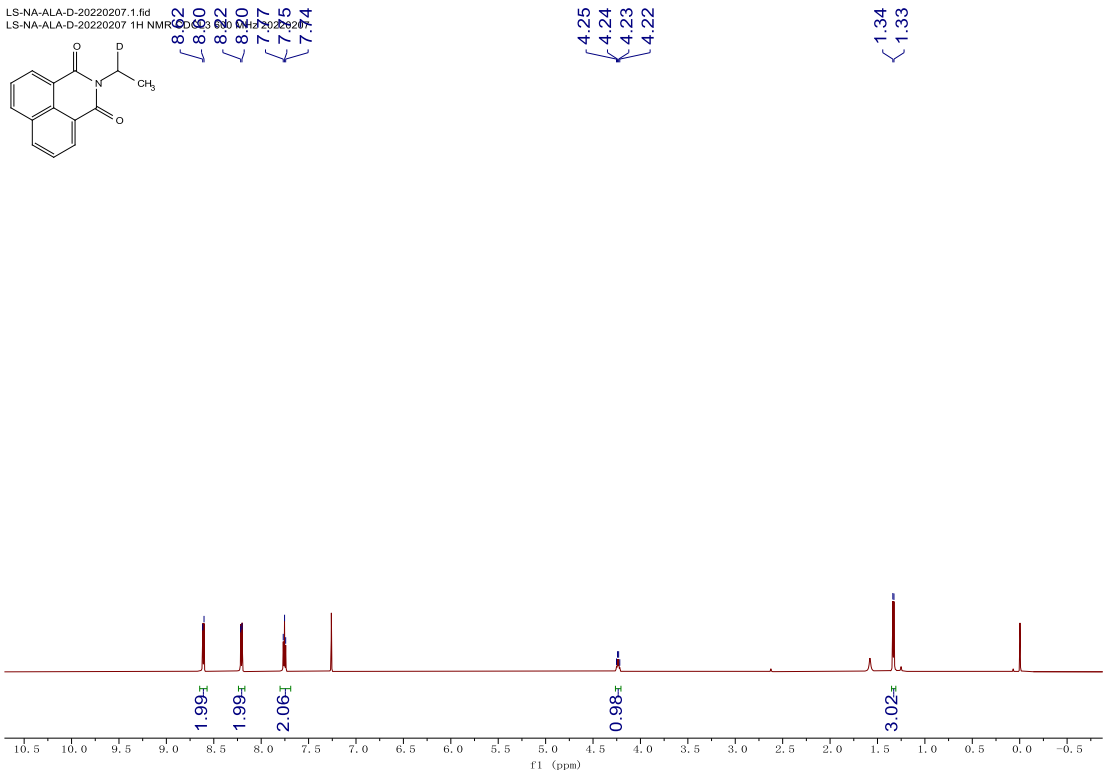
^{13}C NMR spectrum for compound **2a**



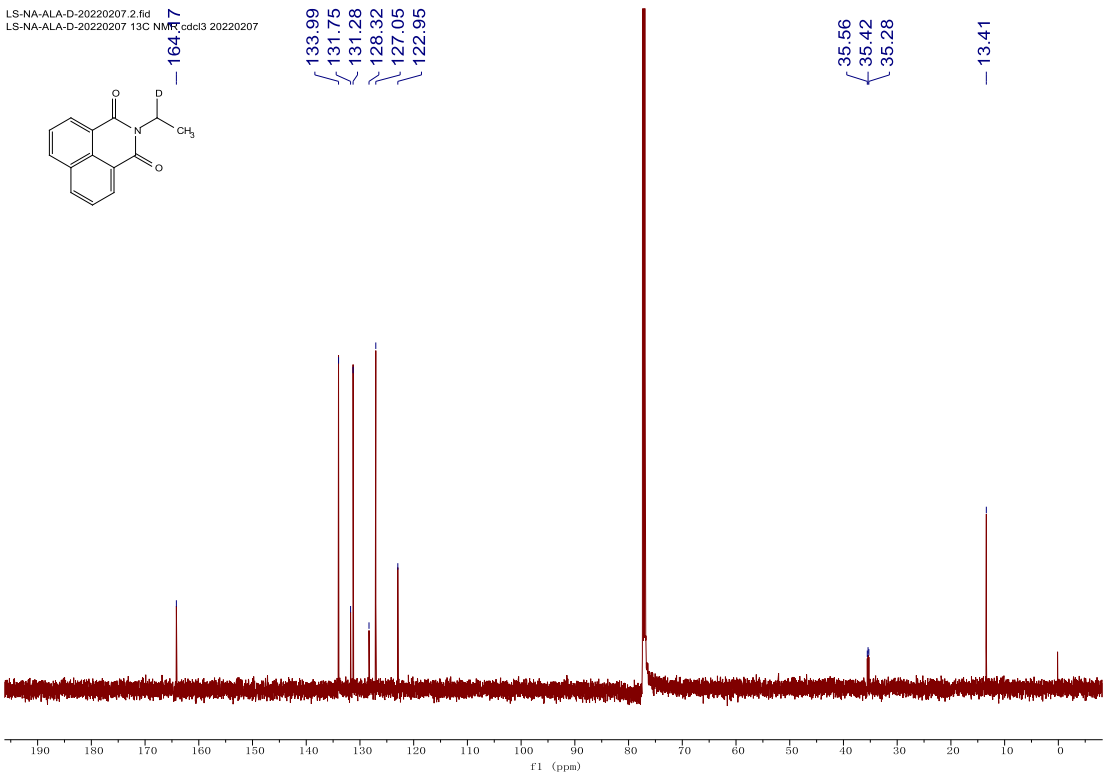
^{1}H NMR spectrum for compound **2d**



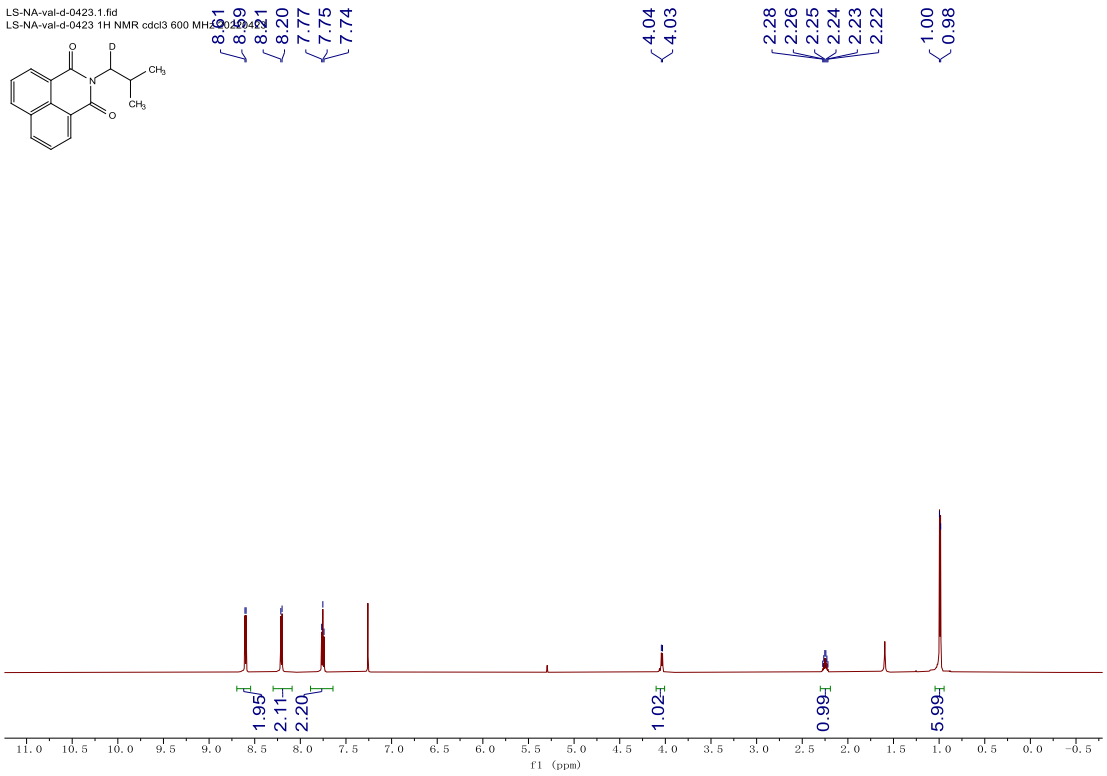
^{13}C NMR spectrum for compound **2d**



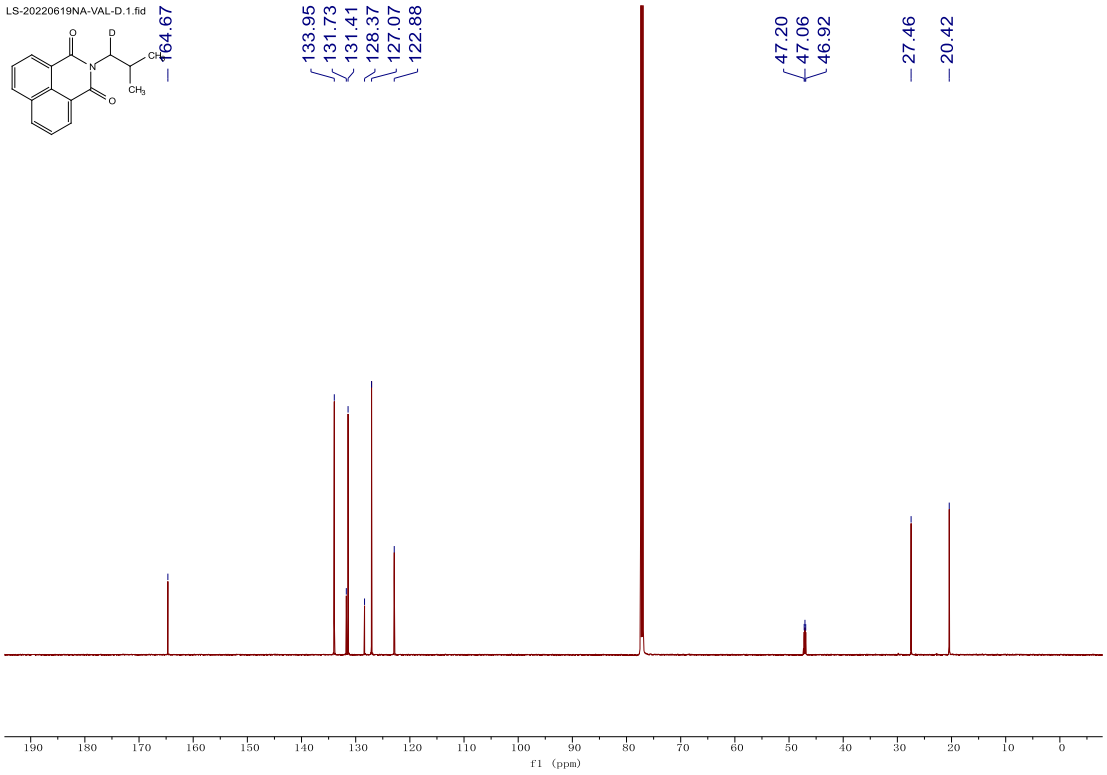
^{1}H NMR spectrum for compound **2e**



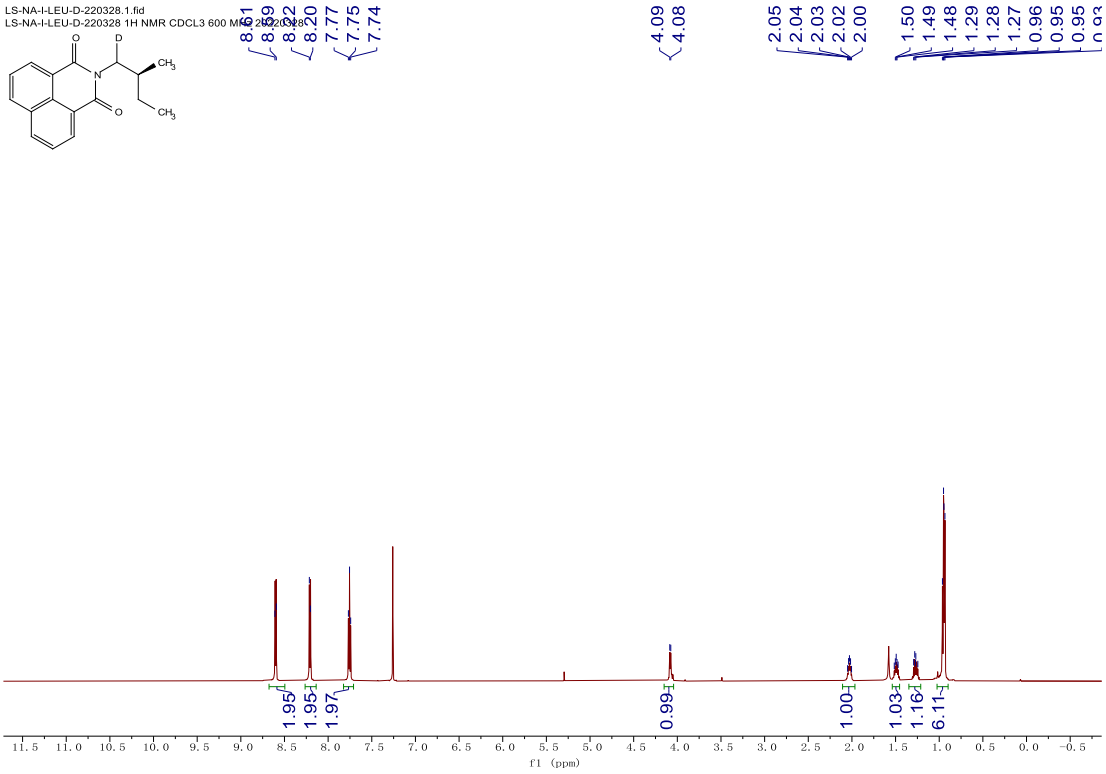
^{13}C NMR spectrum for compound **2e**



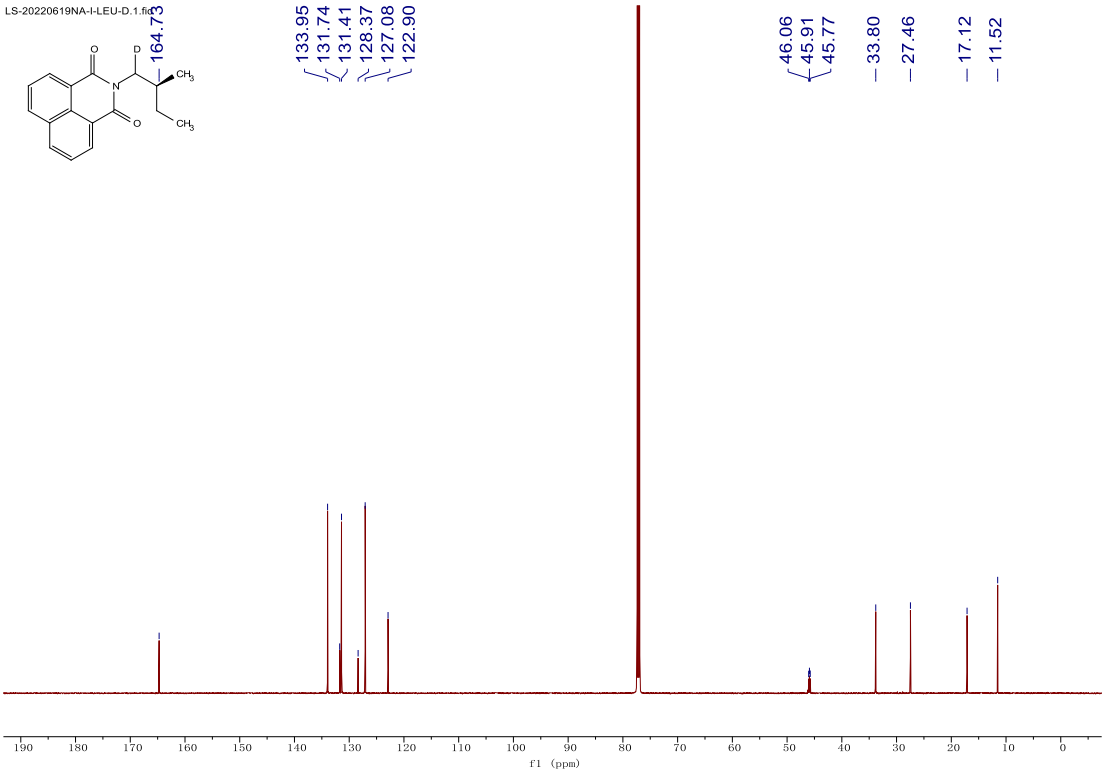
^{1}H NMR spectrum for compound **2f**



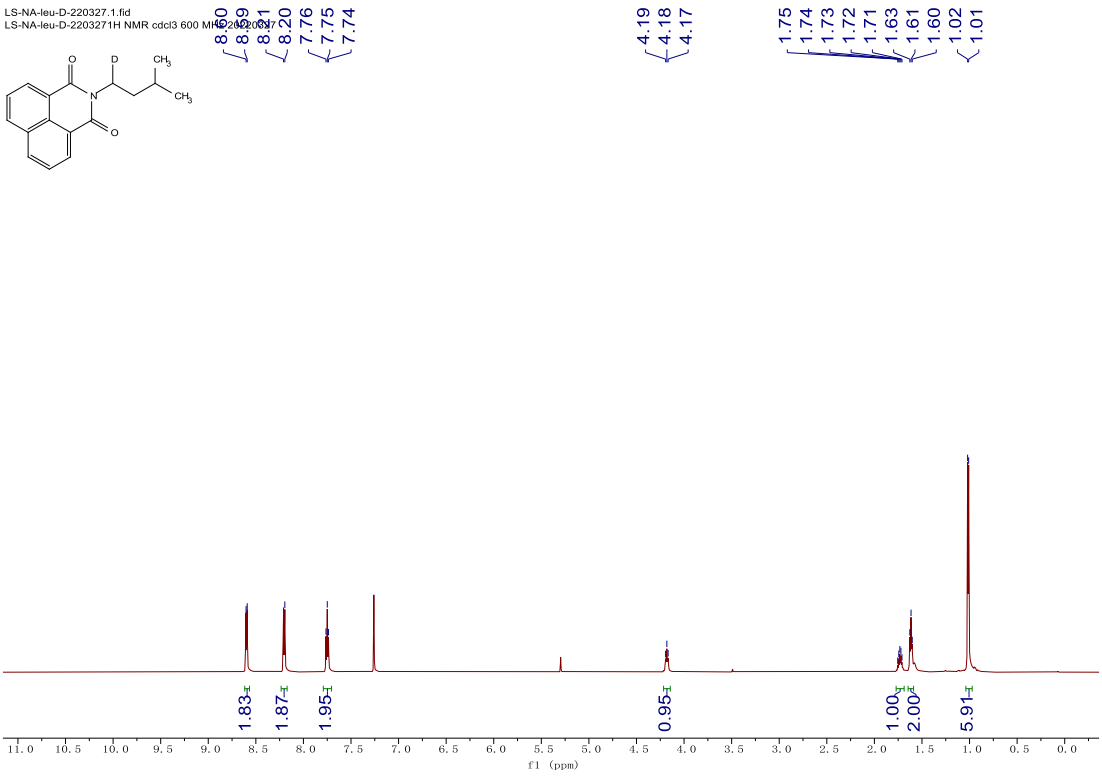
^{13}C NMR spectrum for compound **2f**



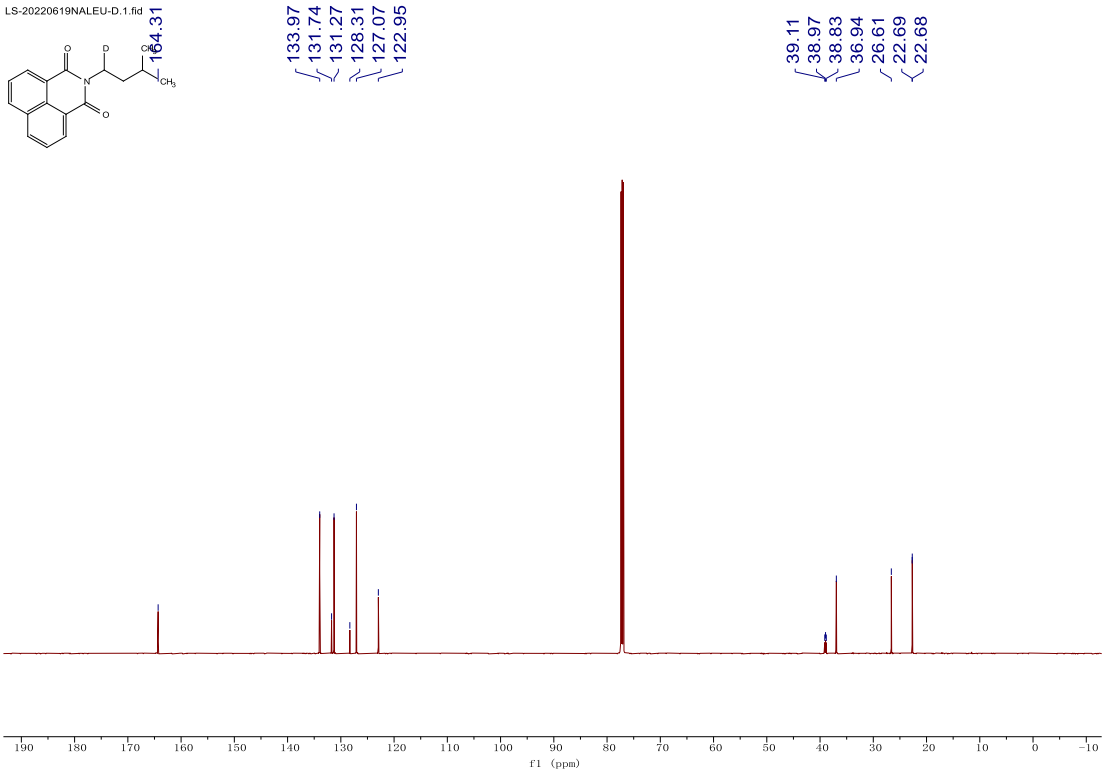
^{1}H NMR spectrum for compound **2g**



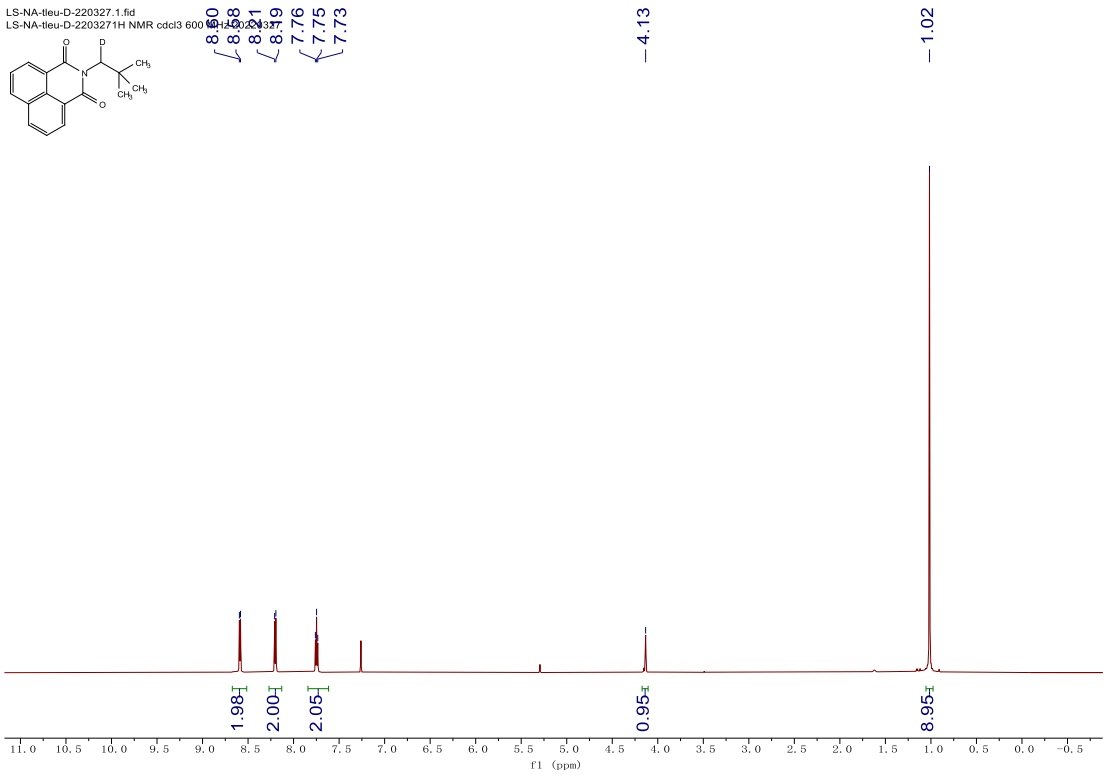
^{13}C NMR spectrum for compound **2g**



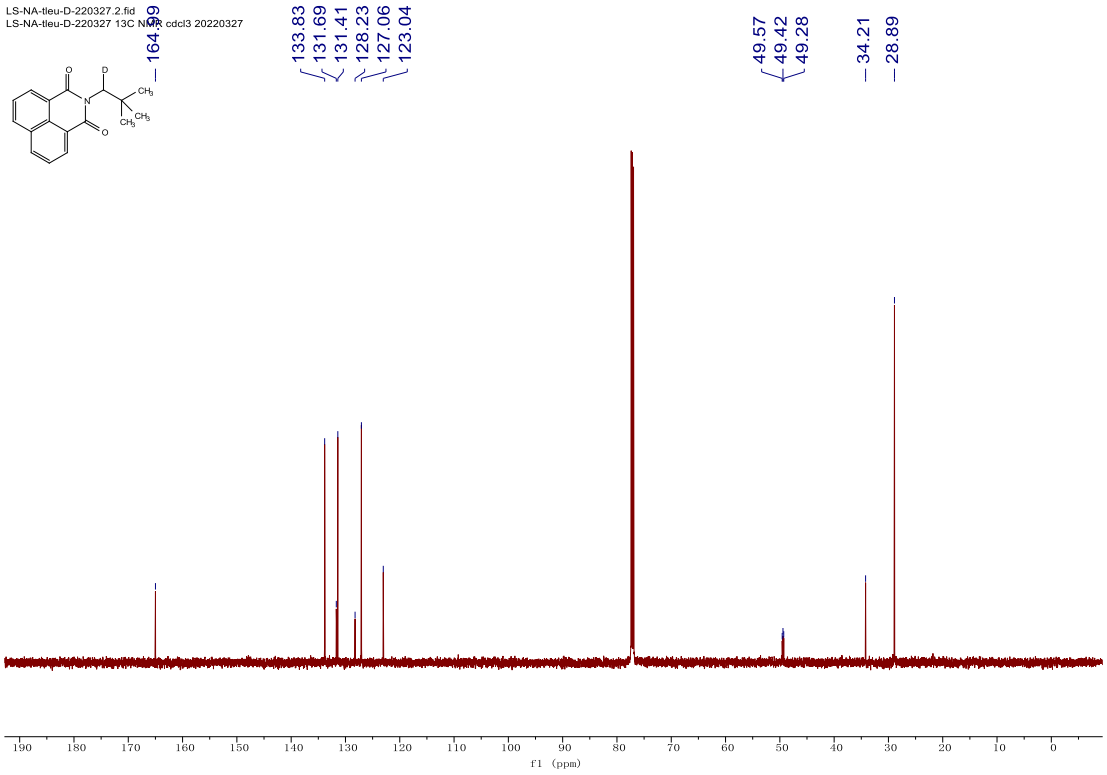
^{1}H NMR spectrum for compound **2h**



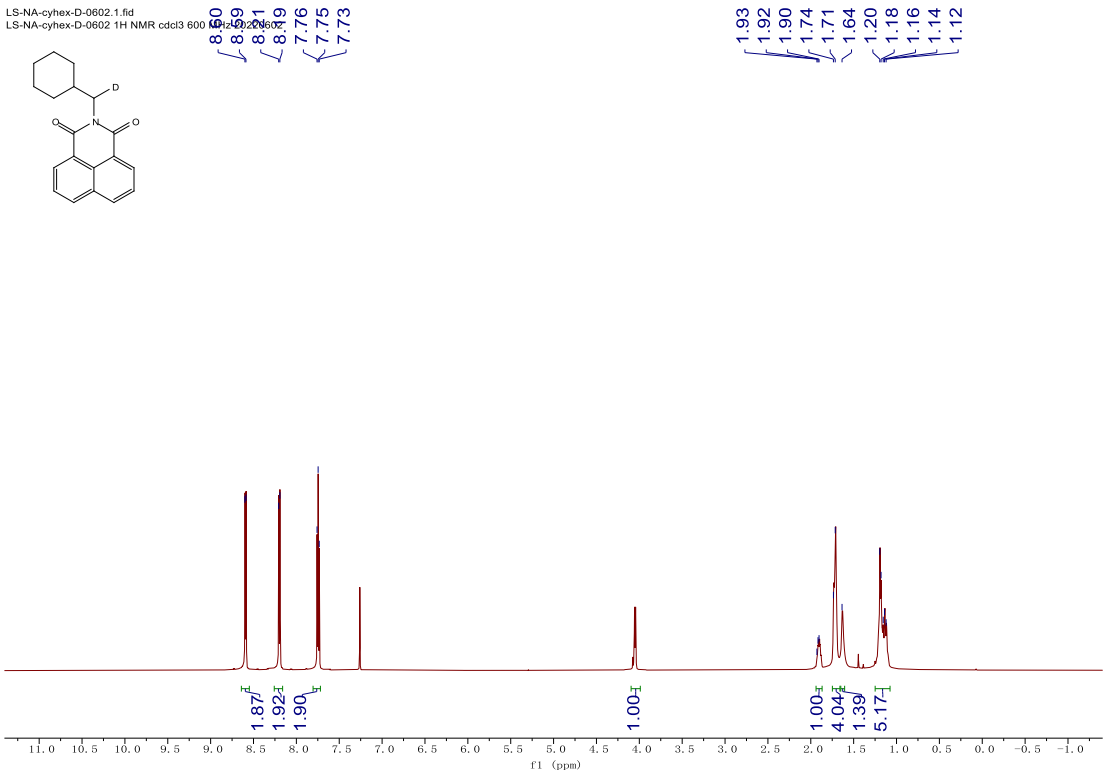
^{13}C NMR spectrum for compound **2h**



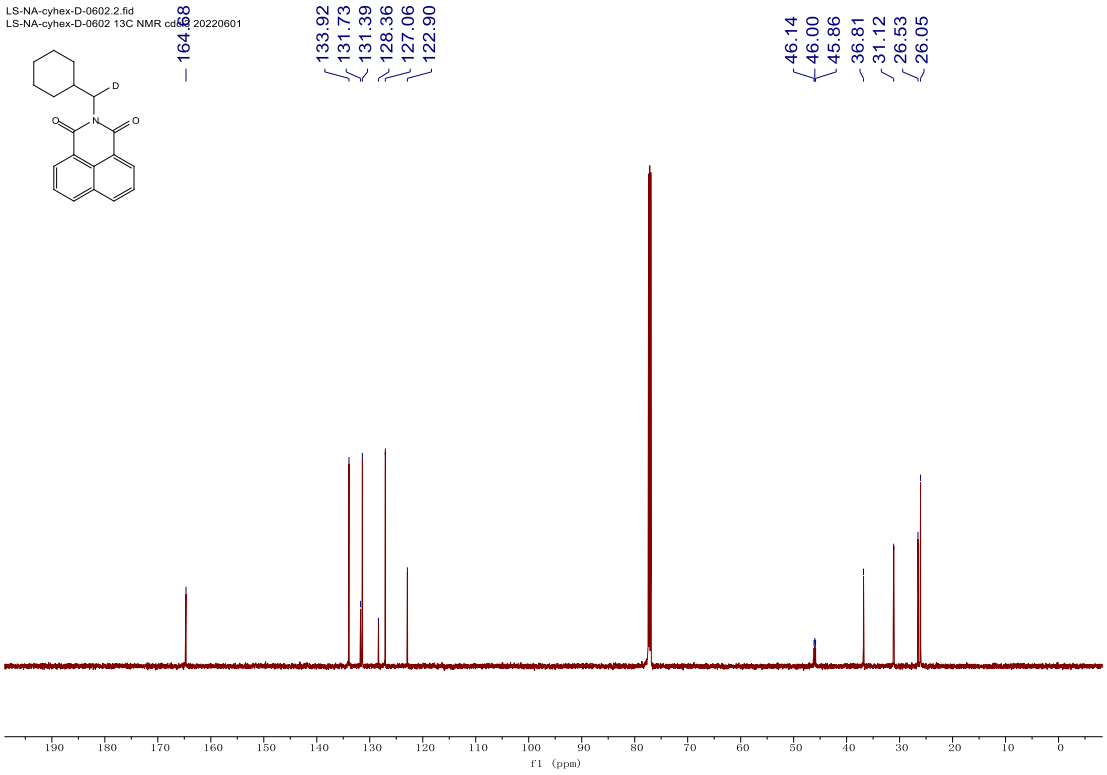
^{1}H NMR spectrum for compound **2i**



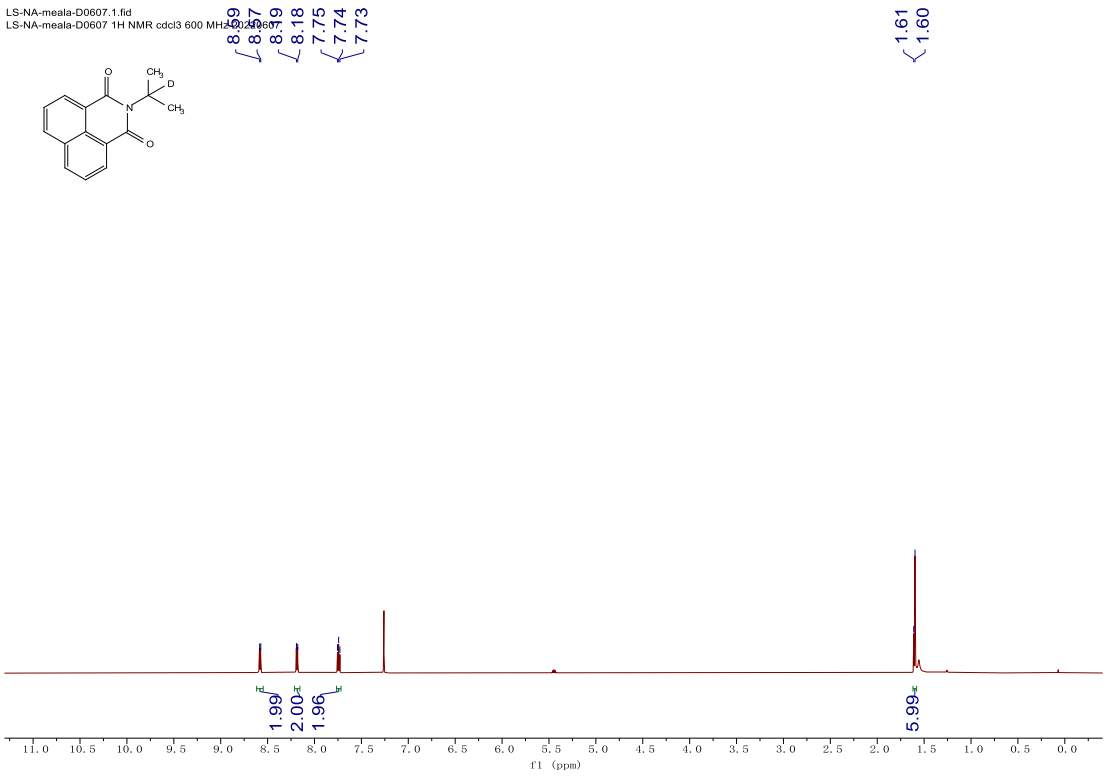
^{13}C NMR spectrum for compound **2i**



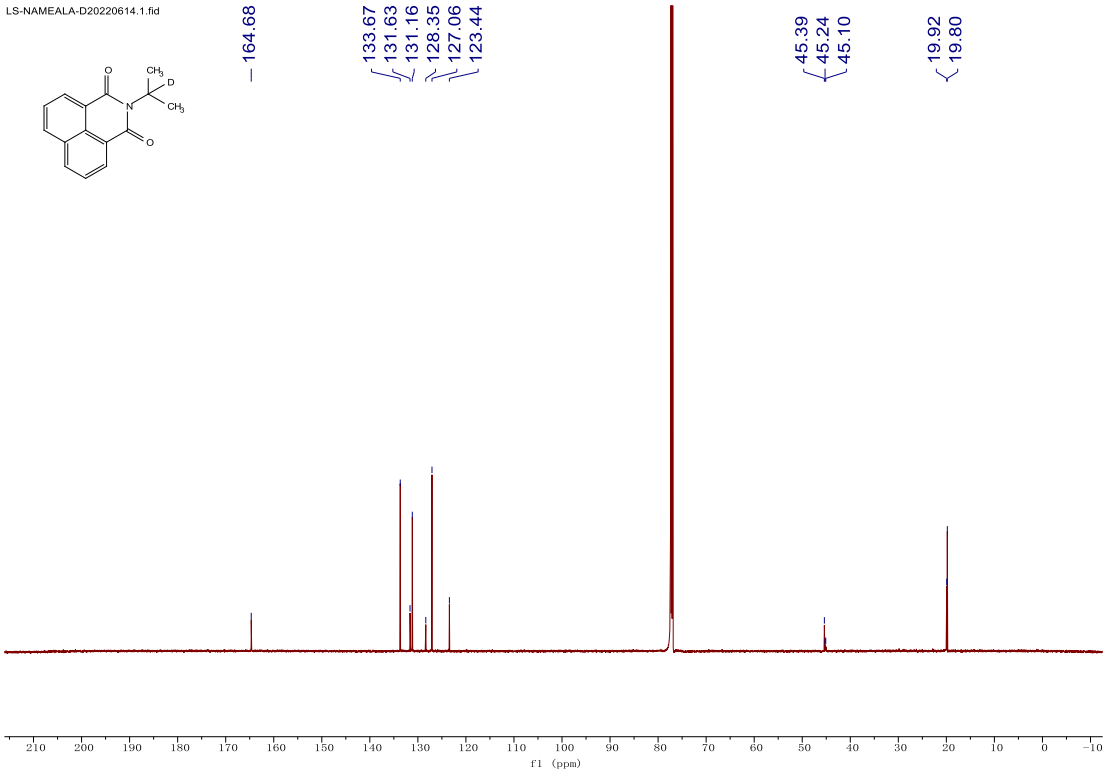
^{1}H NMR spectrum for compound **2j**



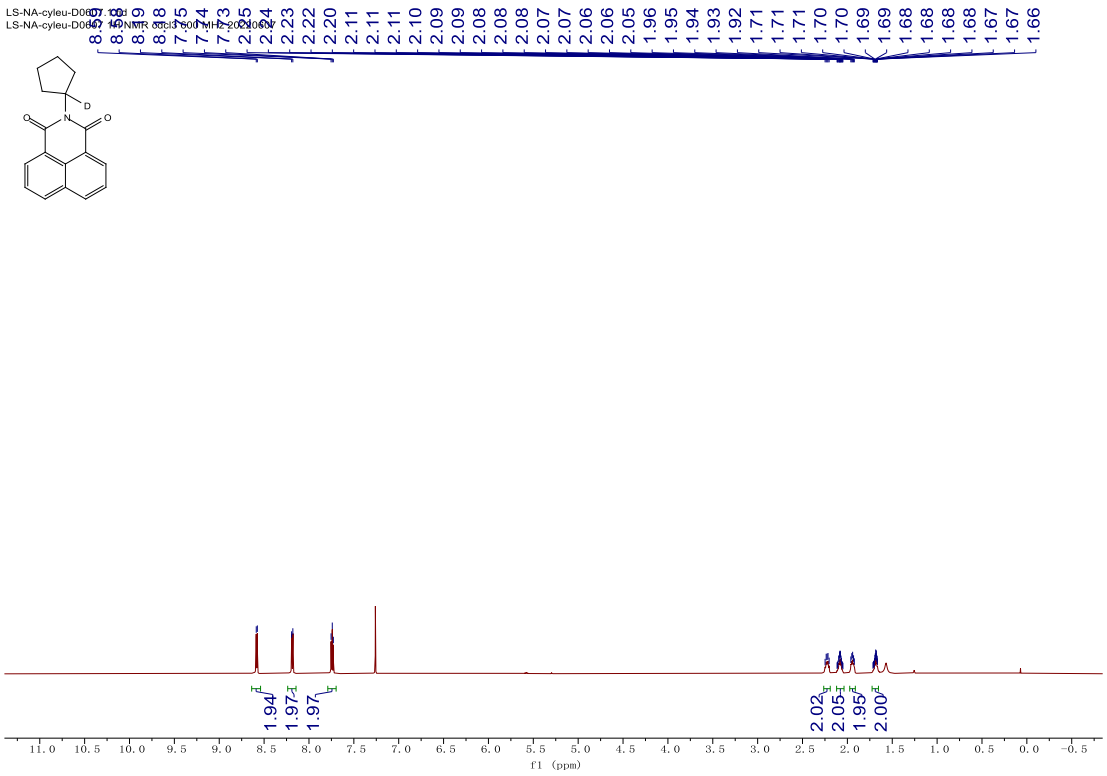
^{13}C NMR spectrum for compound **2j**



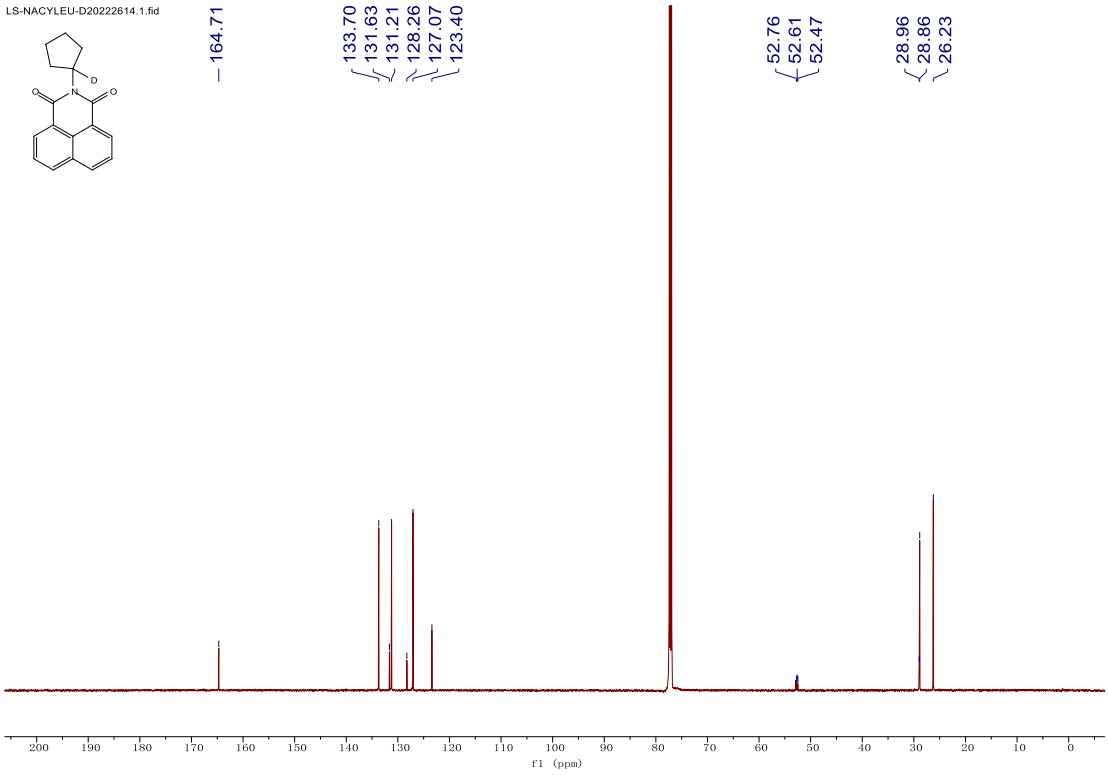
^{1}H NMR spectrum for compound **2k**



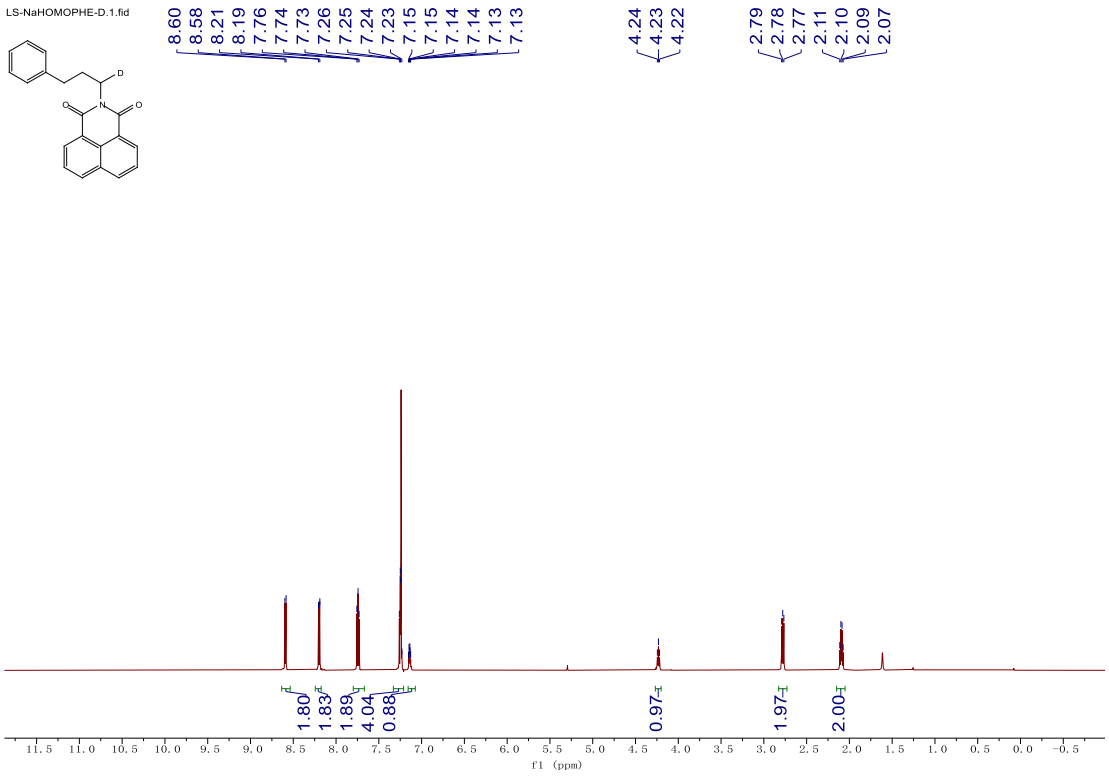
^{13}C NMR spectrum for compound **2k**



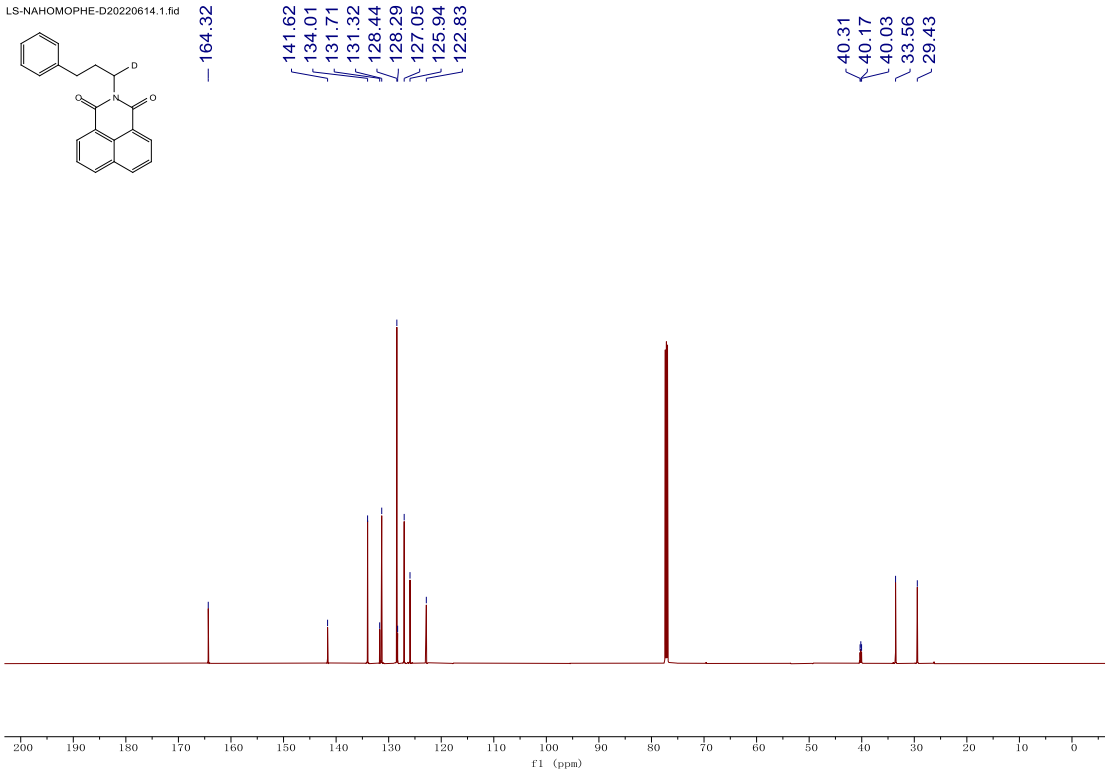
^{1}H NMR spectrum for compound **2l**



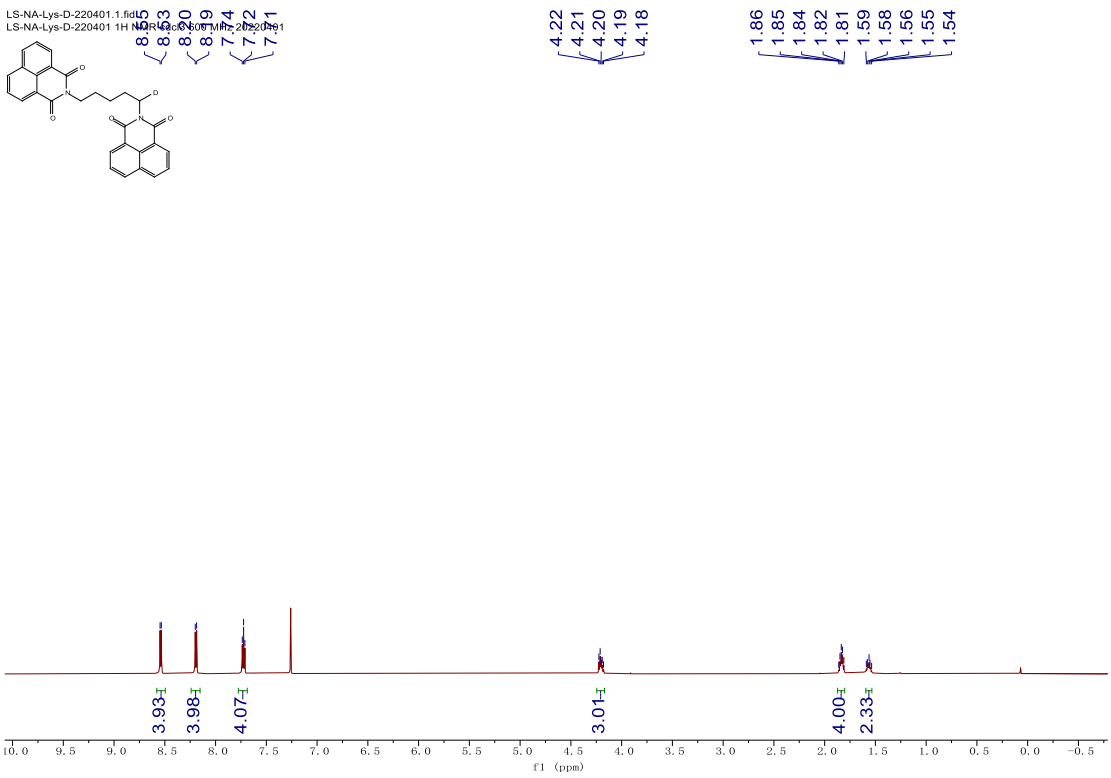
^{13}C NMR spectrum for compound **2l**



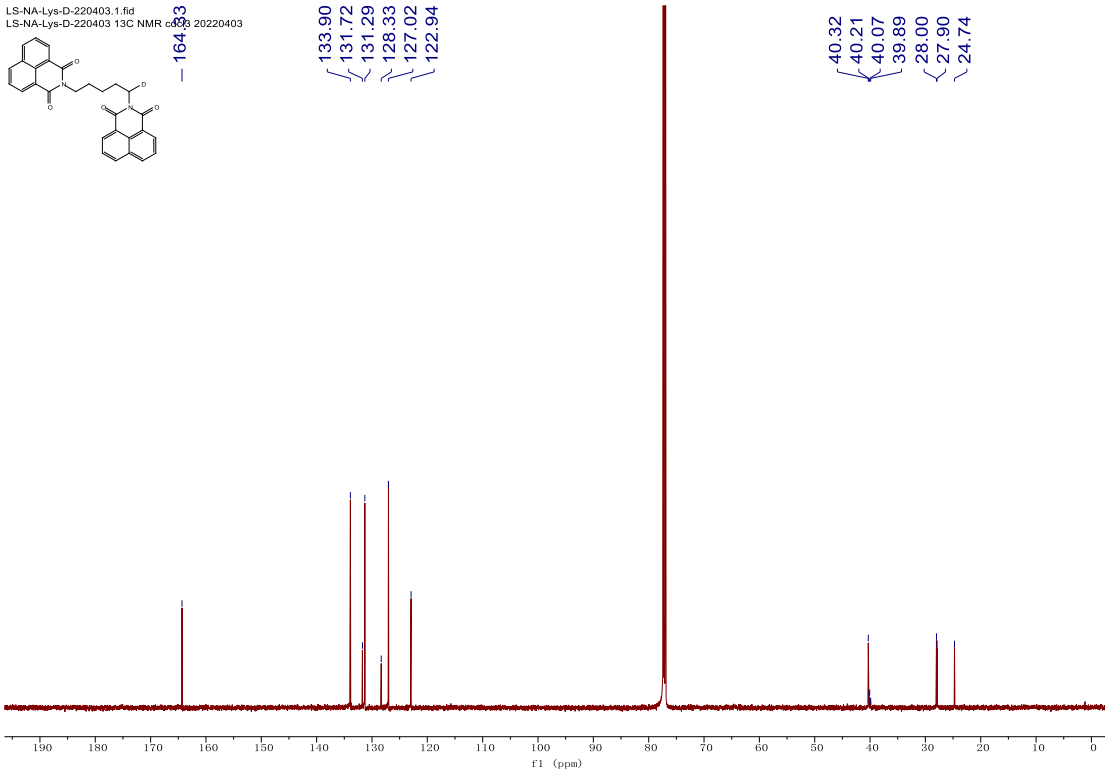
^{1}H NMR spectrum for compound **2m**



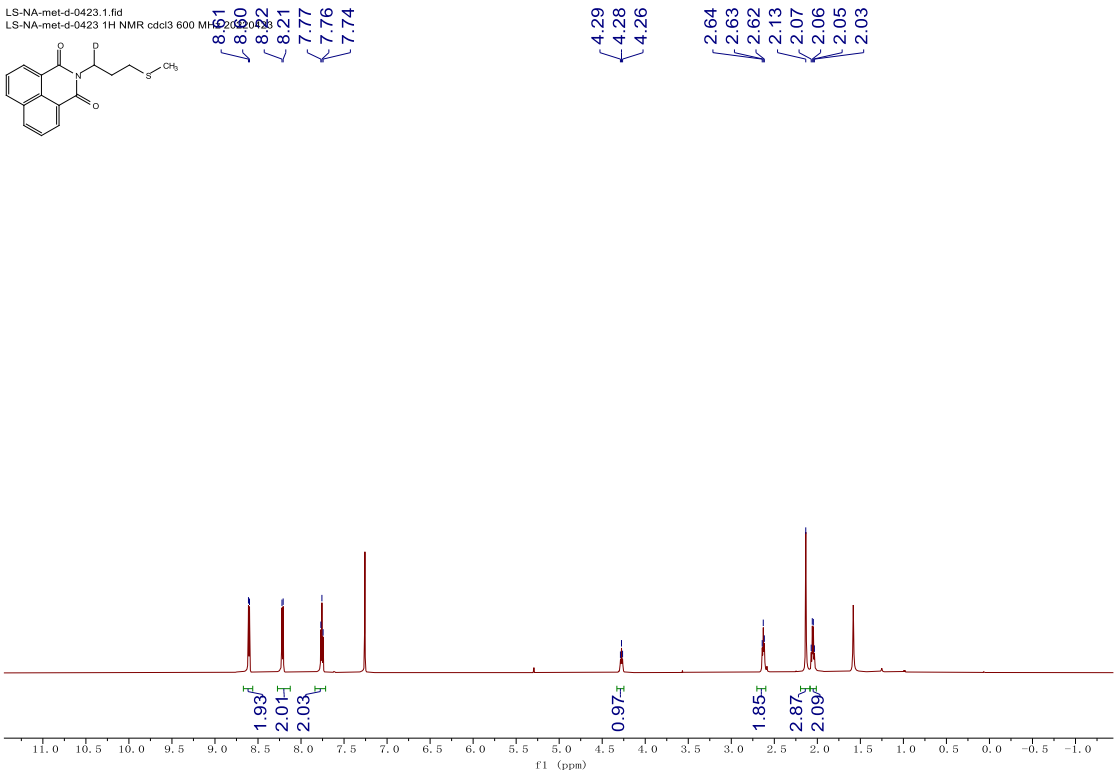
^{13}C NMR spectrum for compound **2m**



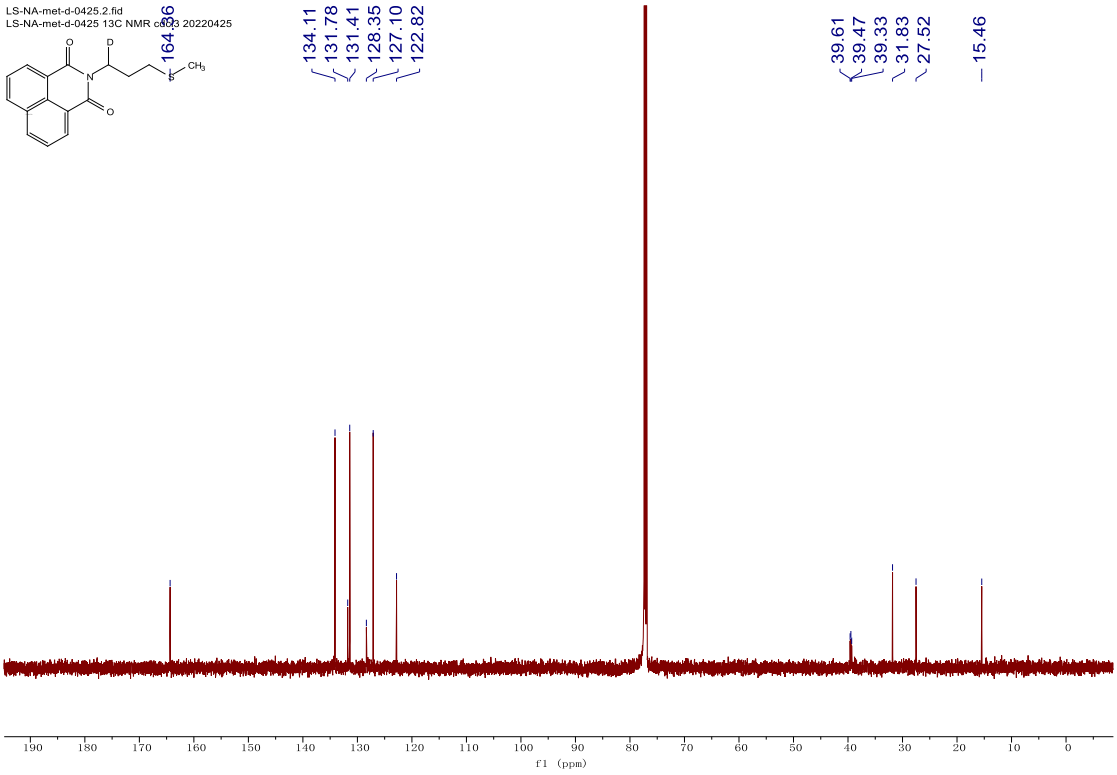
^{1}H NMR spectrum for compound **2n**



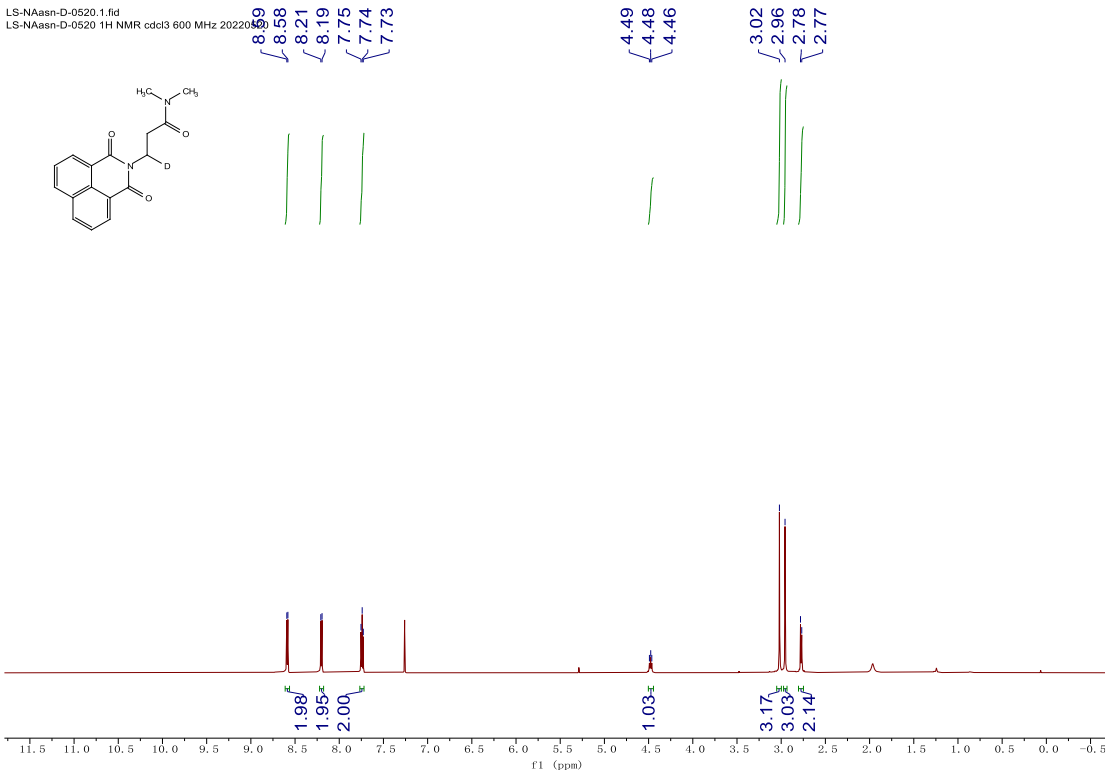
^{13}C NMR spectrum for compound **2n**



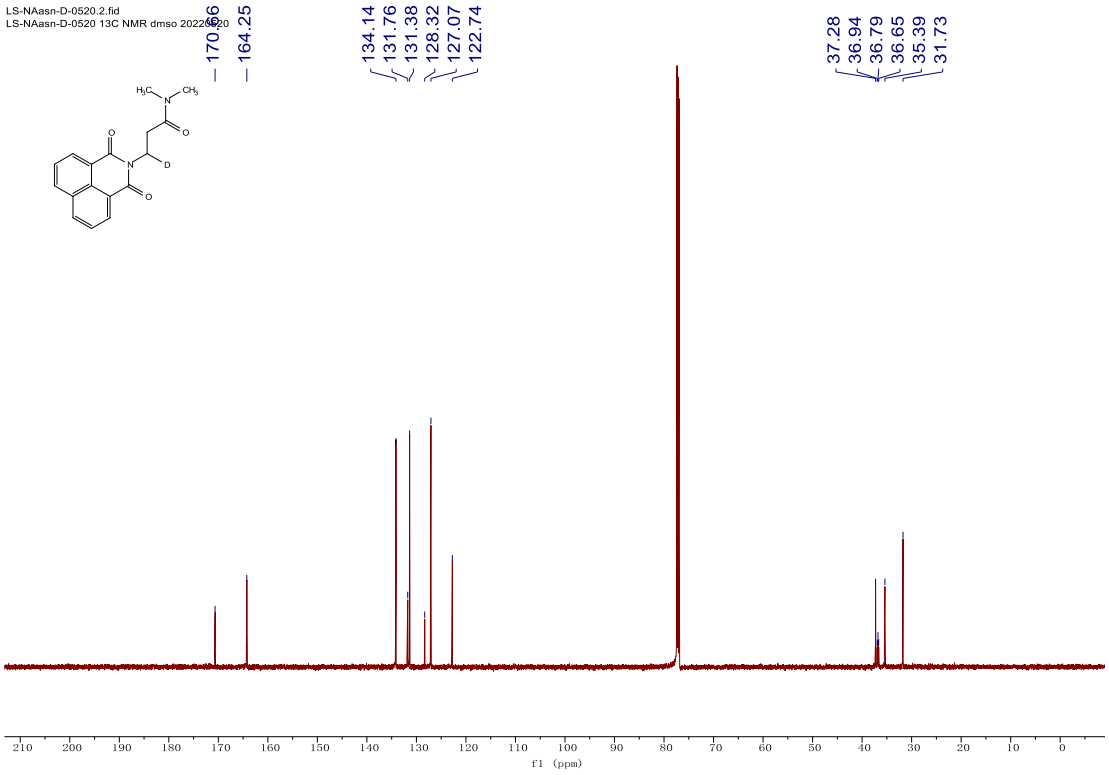
^{1}H NMR spectrum for compound **2o**



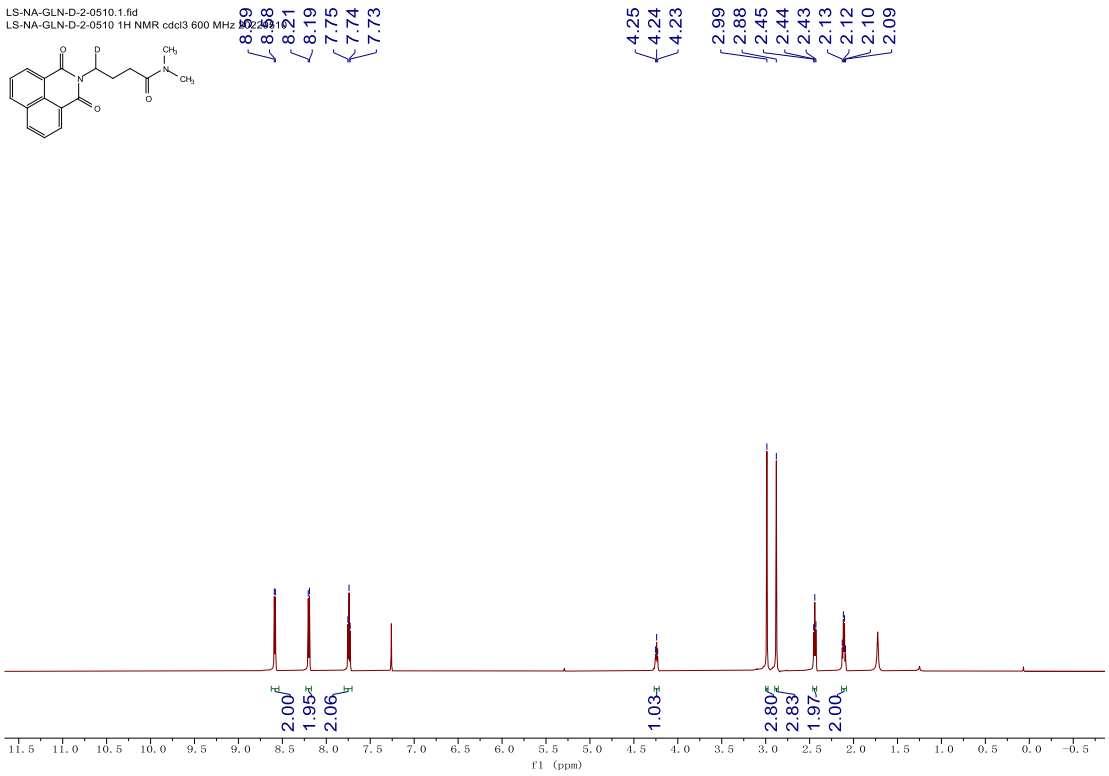
^{13}C NMR spectrum for compound **2o**



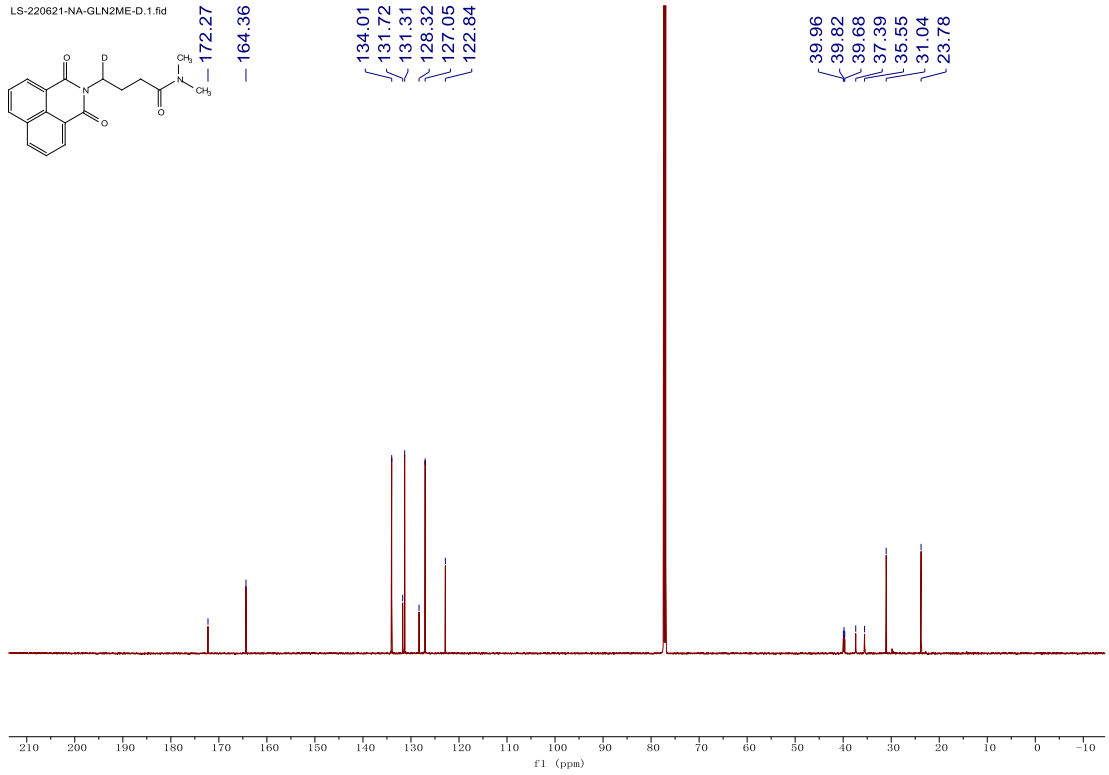
^{1}H NMR spectrum for compound **2p**



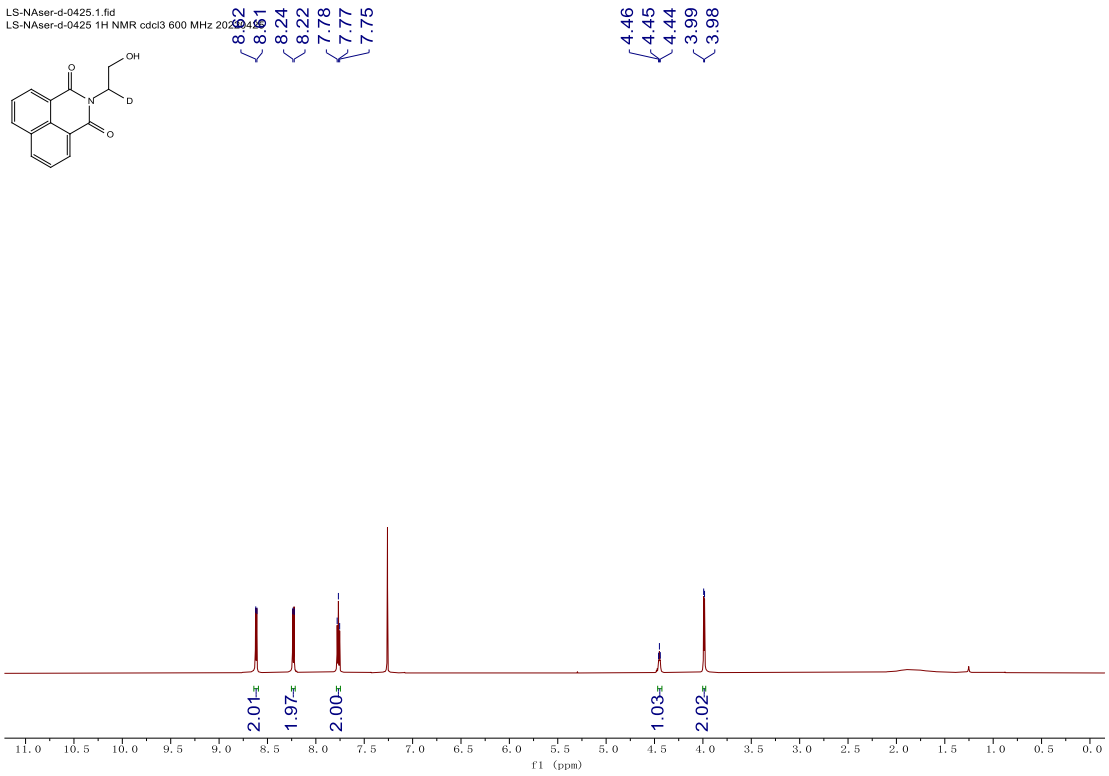
^{13}C NMR spectrum for compound **2p**



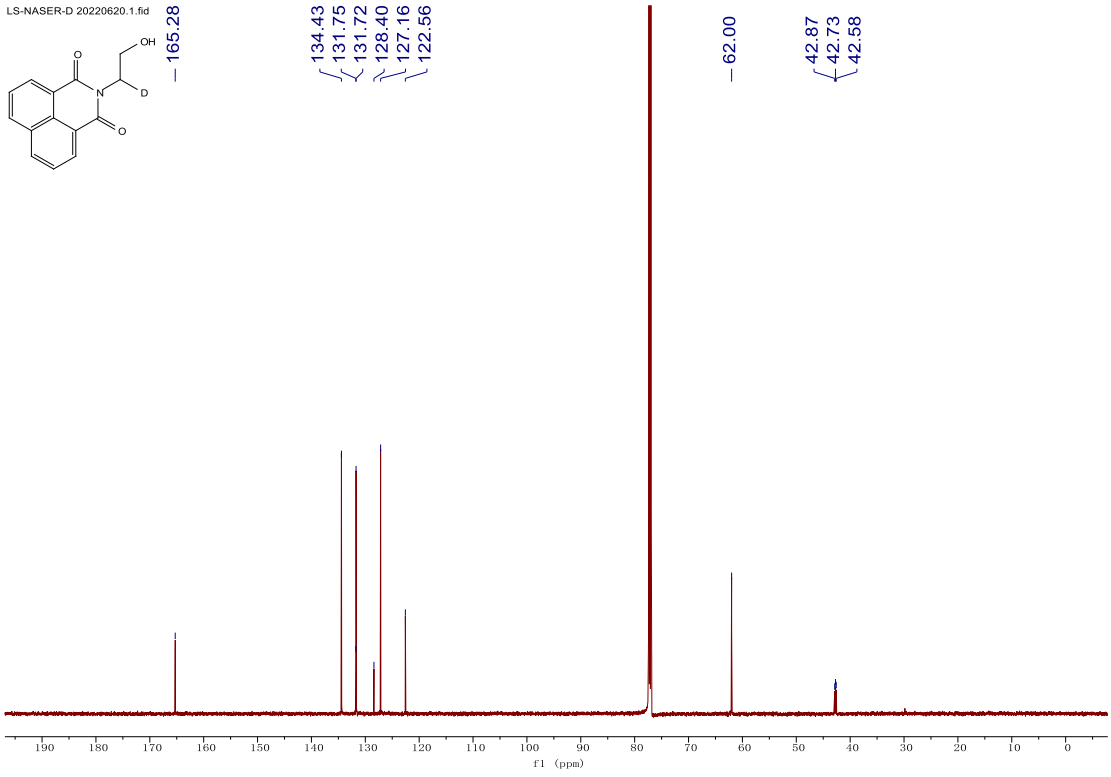
^{1}H NMR spectrum for compound **2q**



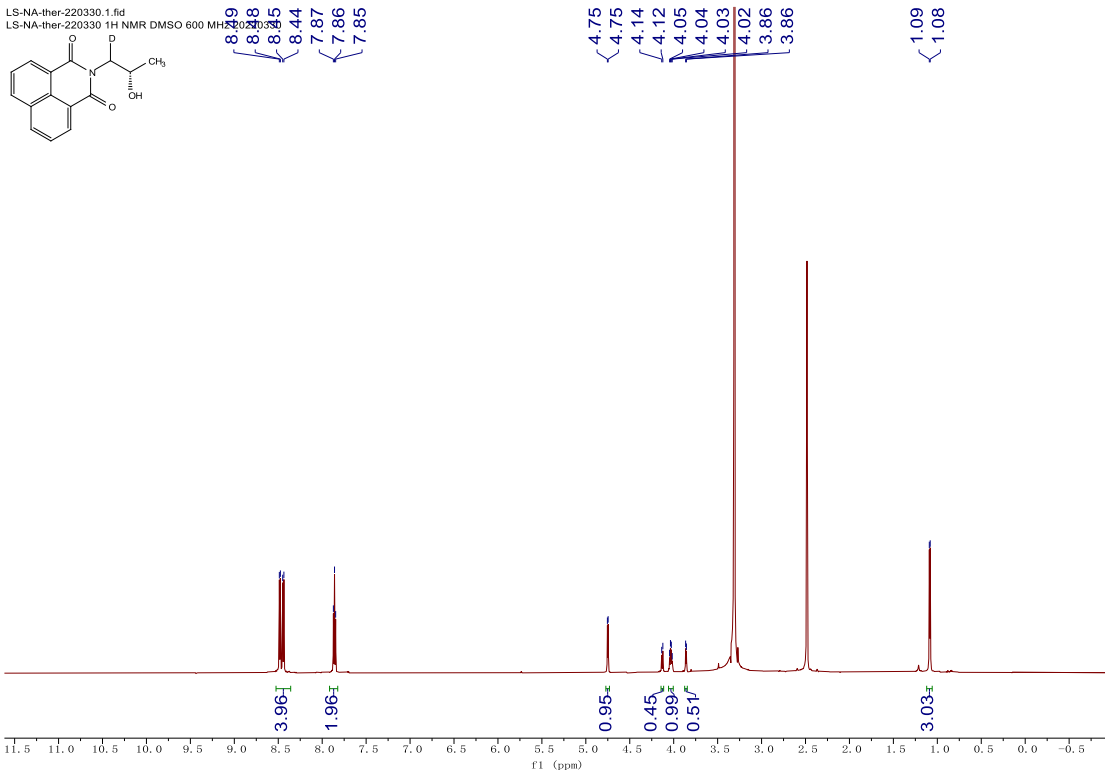
^{13}C NMR spectrum for compound **2q**



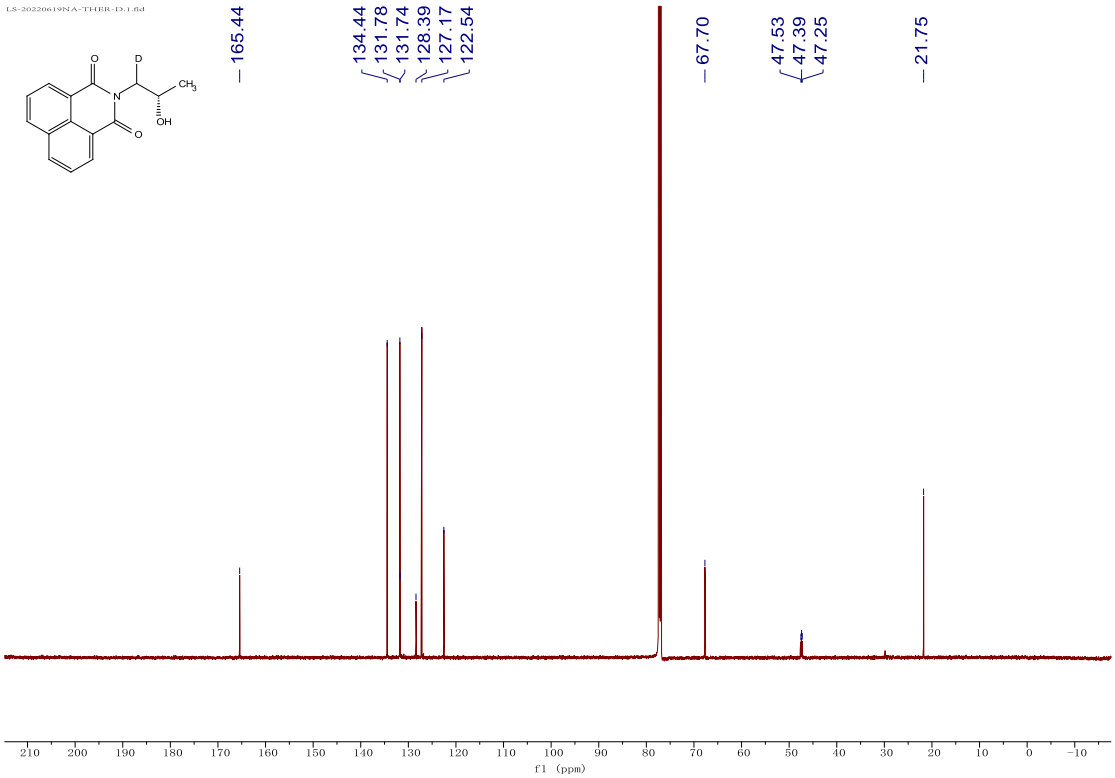
^{1}H NMR spectrum for compound **2r**



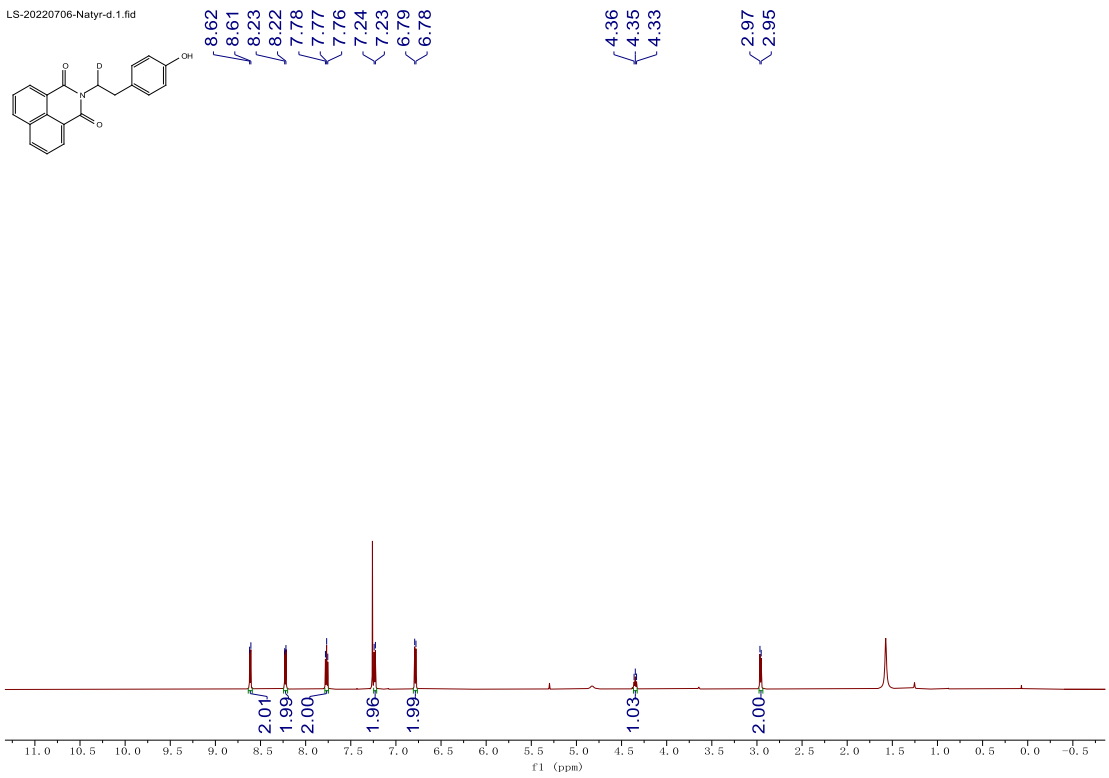
^{13}C NMR spectrum for compound **2r**



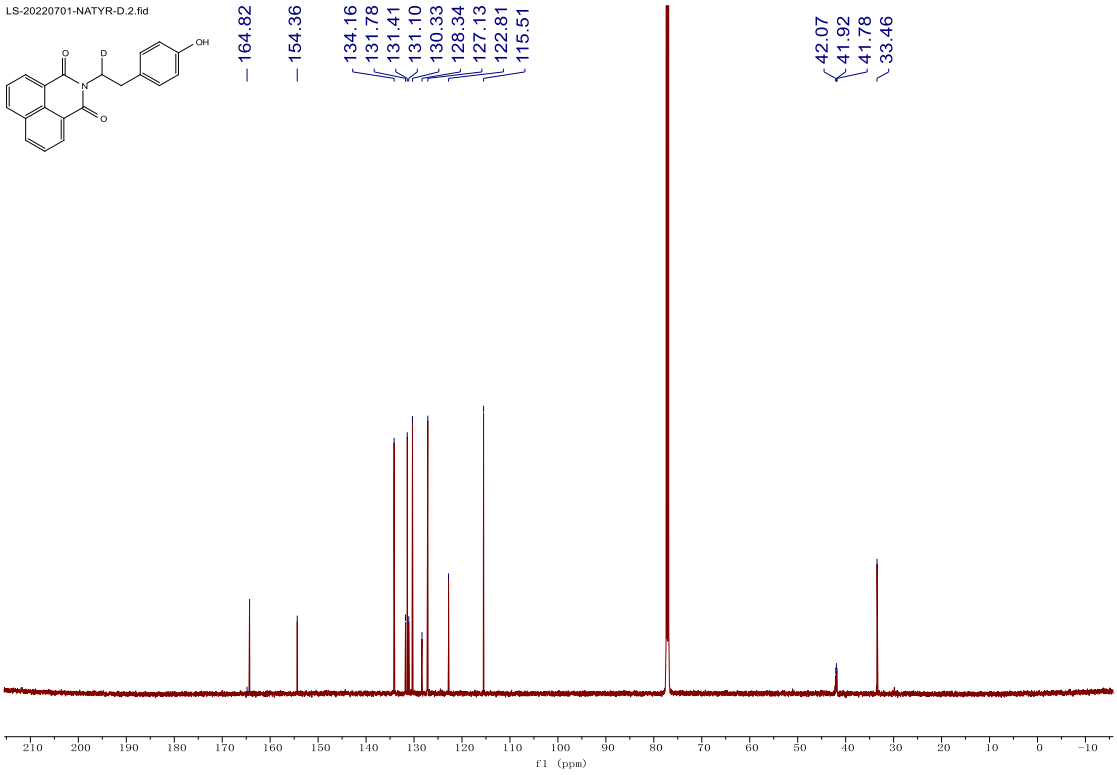
^{1}H NMR spectrum for compound **2s**



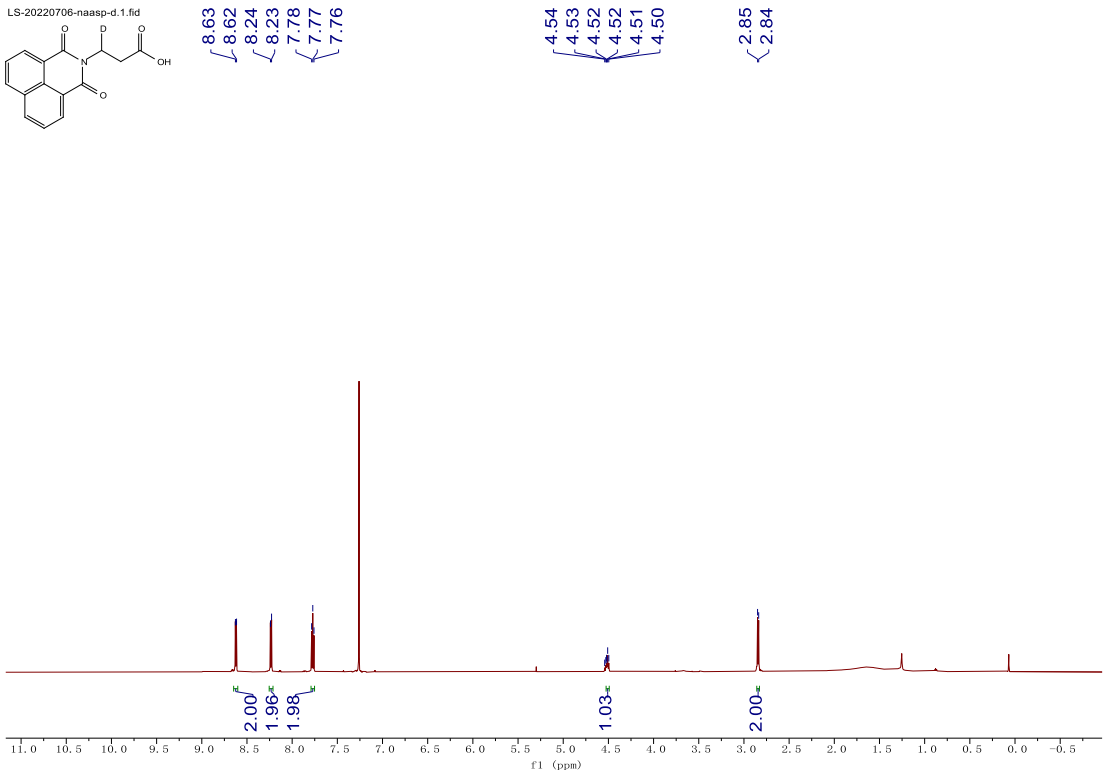
^{13}C NMR spectrum for compound **2s**



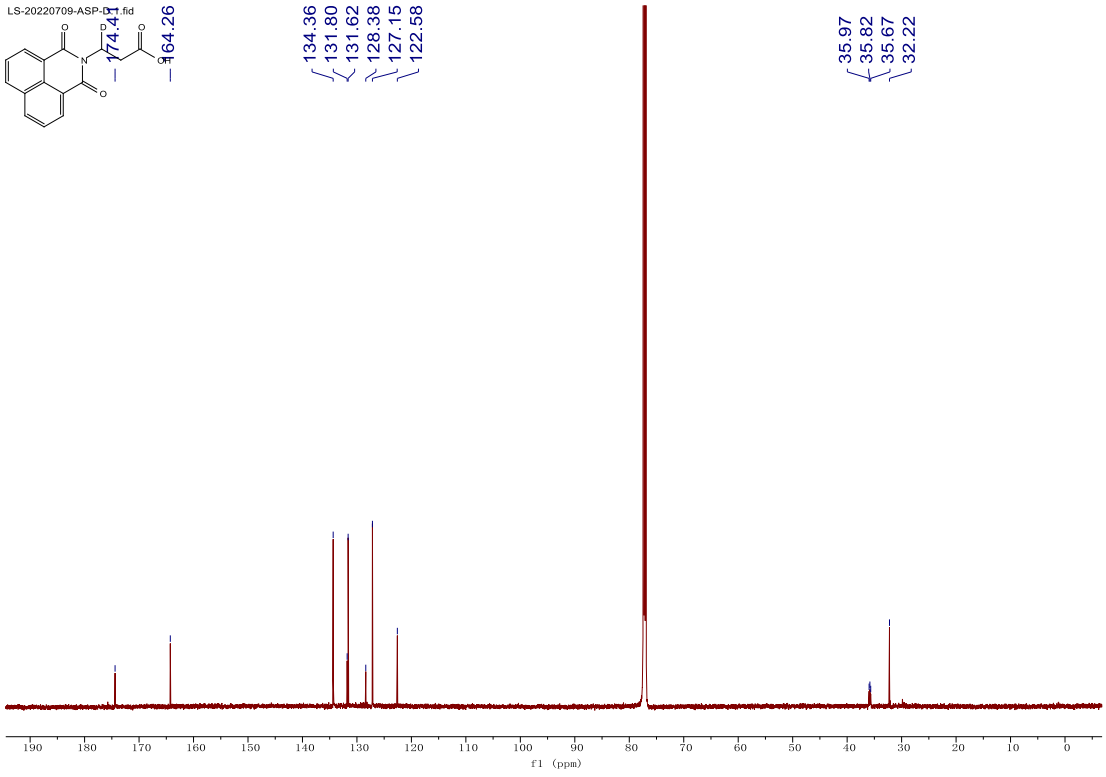
^{1}H NMR spectrum for compound **2t**



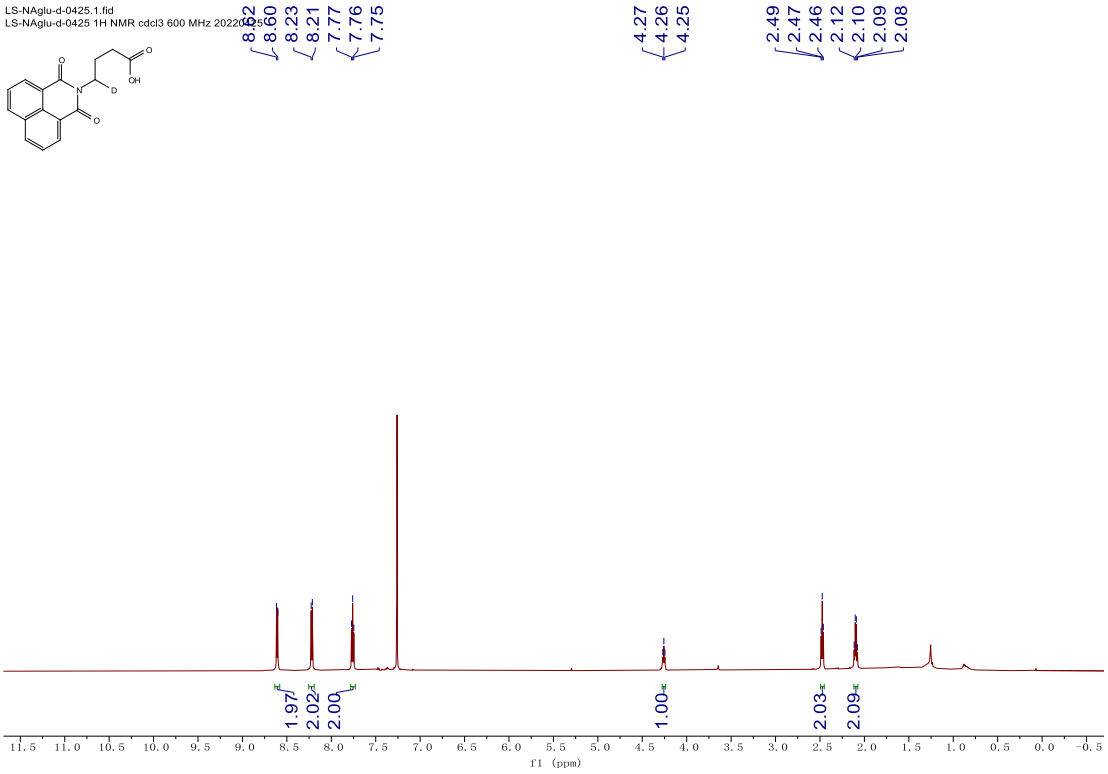
^{13}C NMR spectrum for compound **2t**



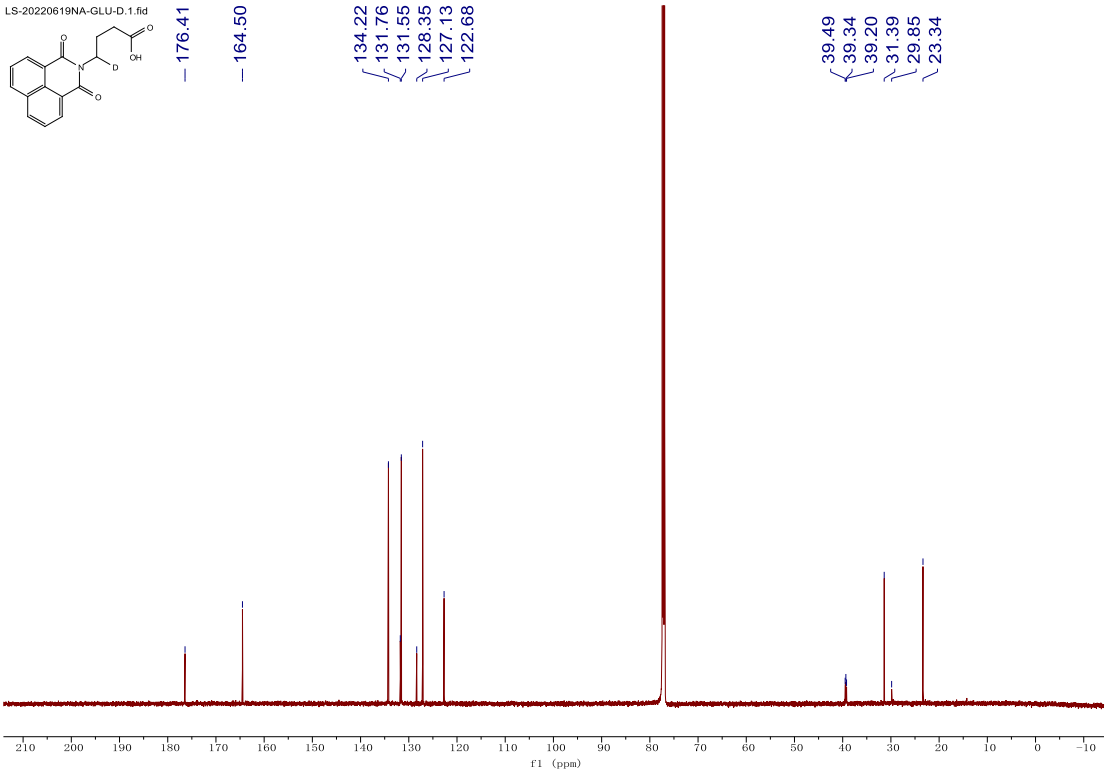
^{1}H NMR spectrum for compound **2u**



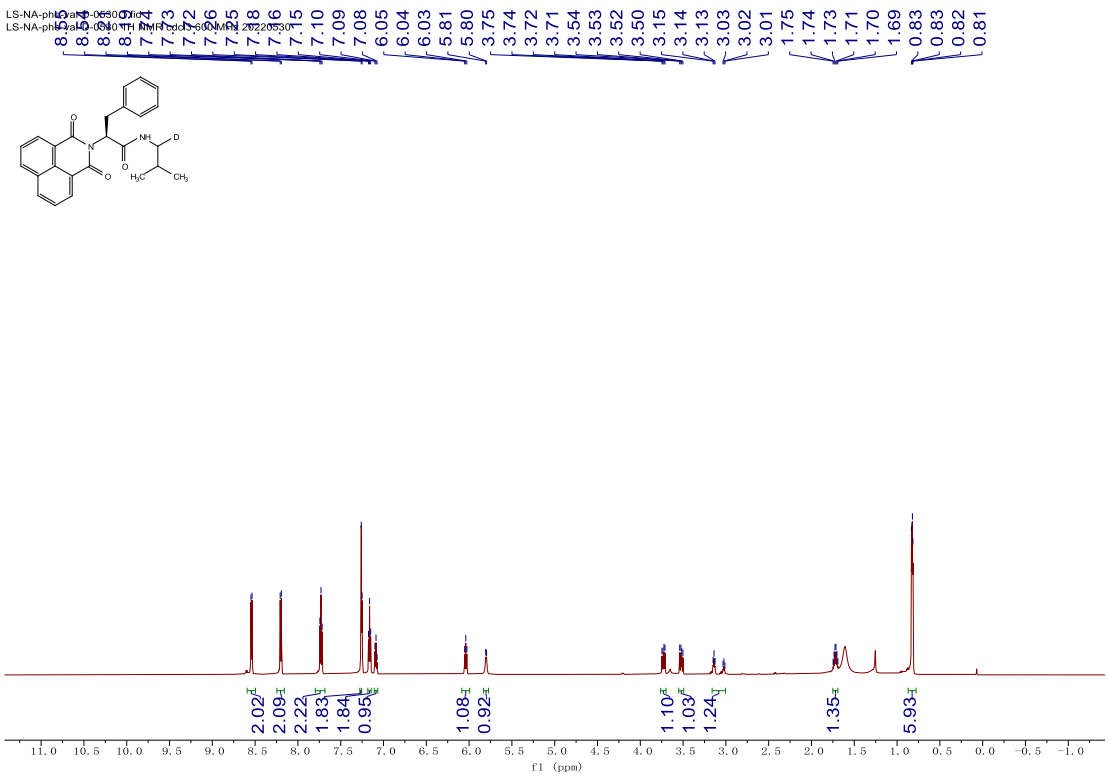
^{13}C NMR spectrum for compound **2u**



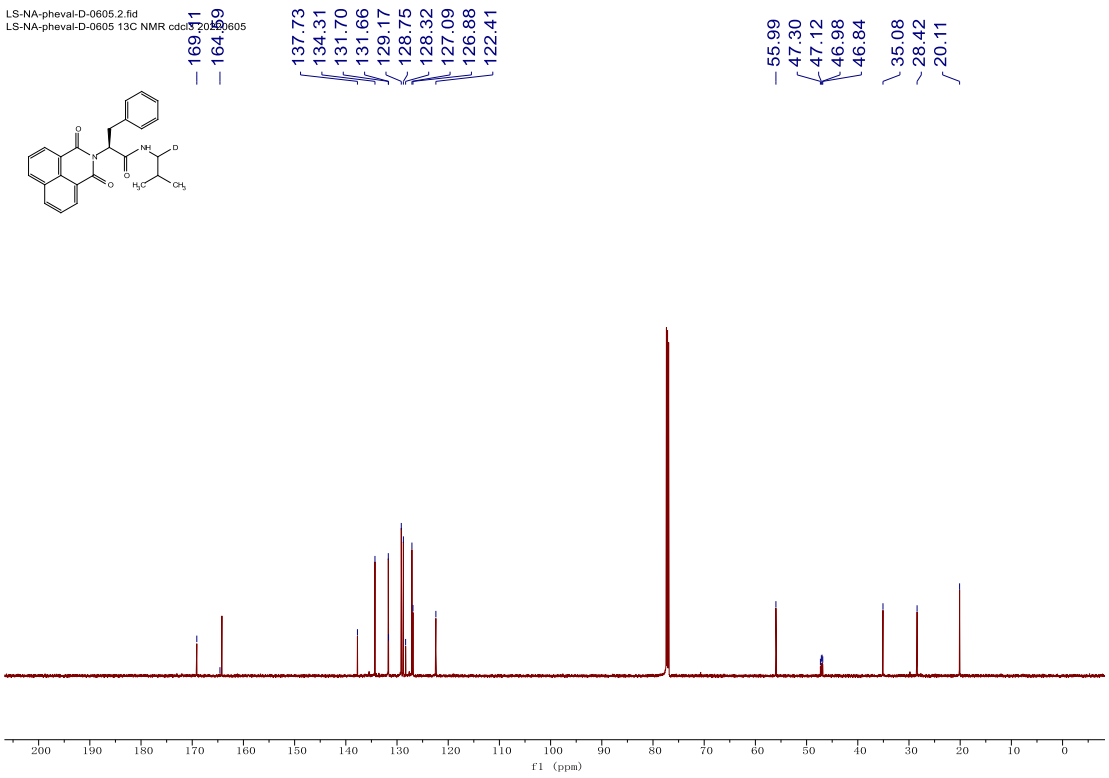
^{1}H NMR spectrum for compound **2v**



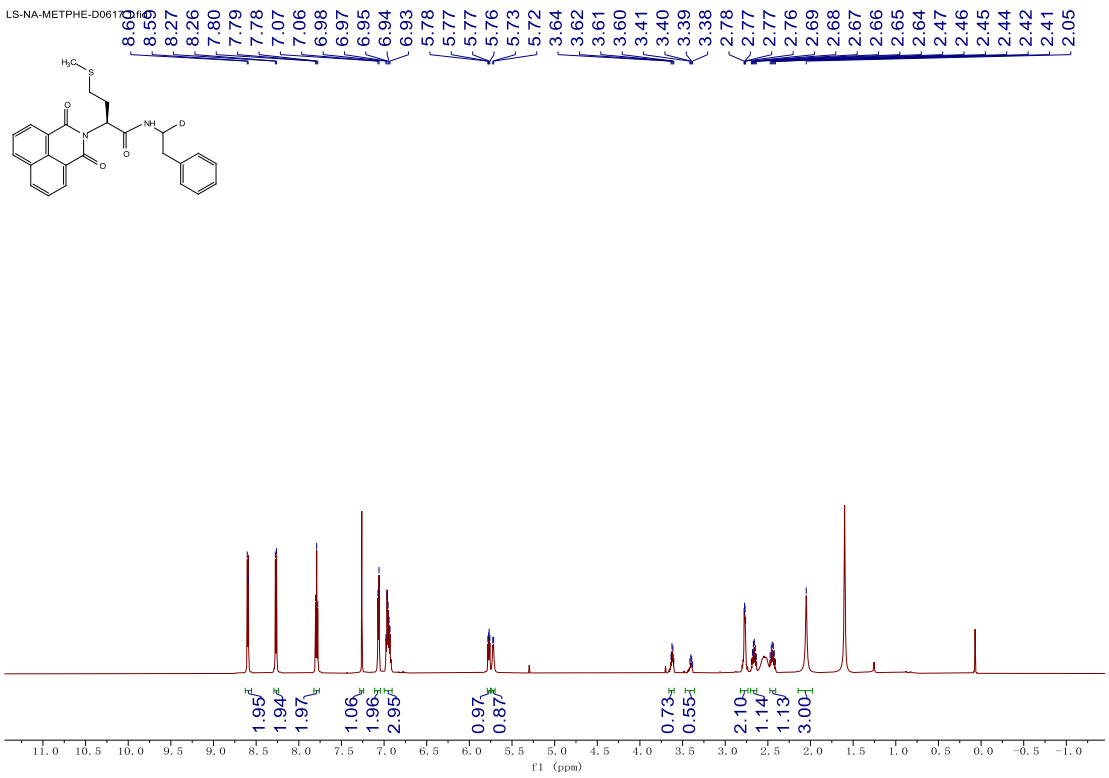
^{13}C NMR spectrum for compound **2v**



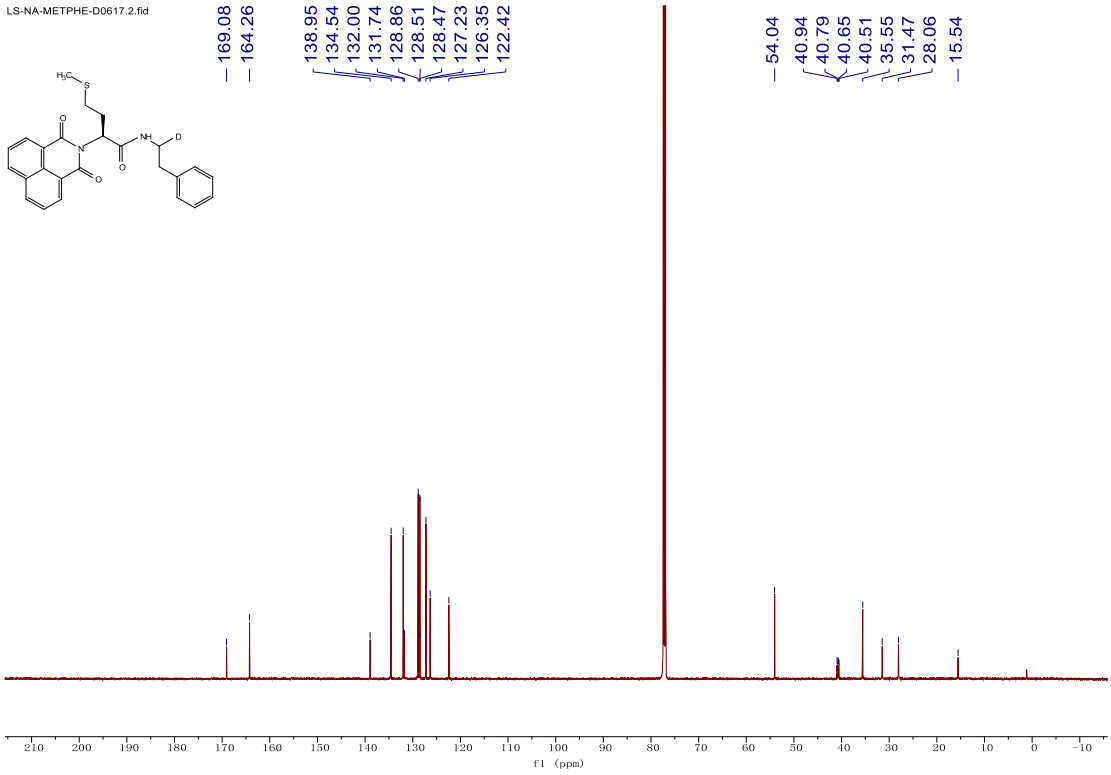
^{1}H NMR spectrum for compound **2w**



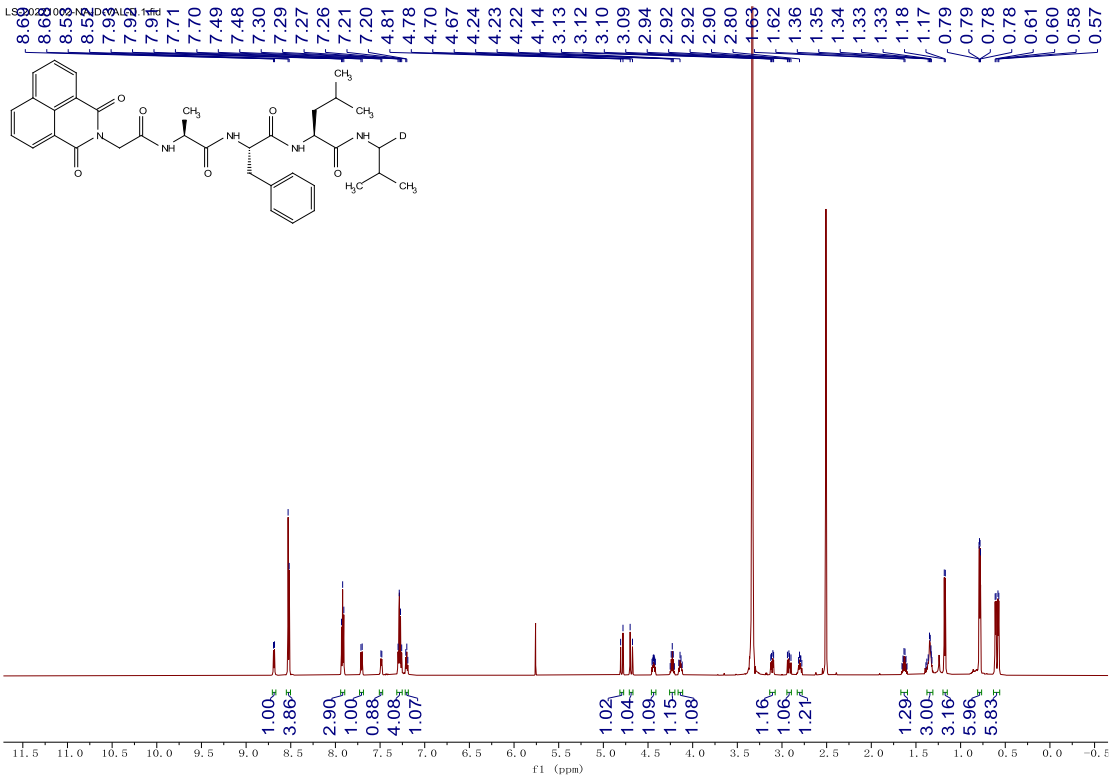
^{13}C NMR spectrum for compound **2w**



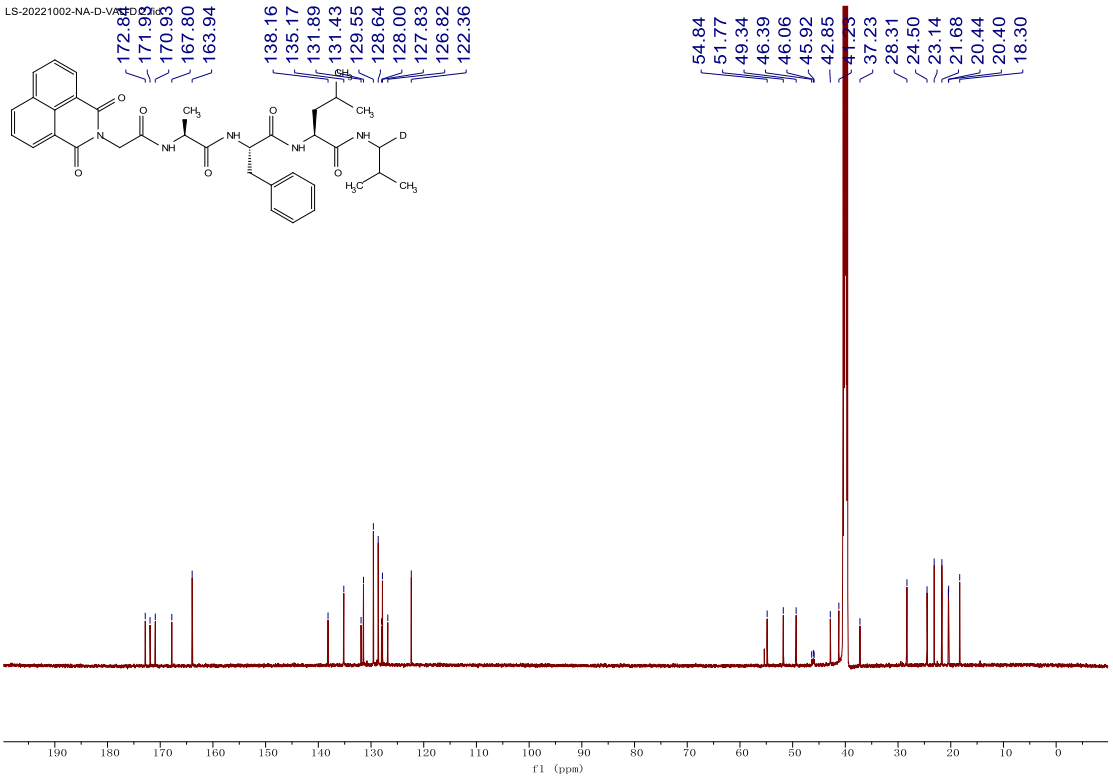
^{1}H NMR spectrum for compound **2x**



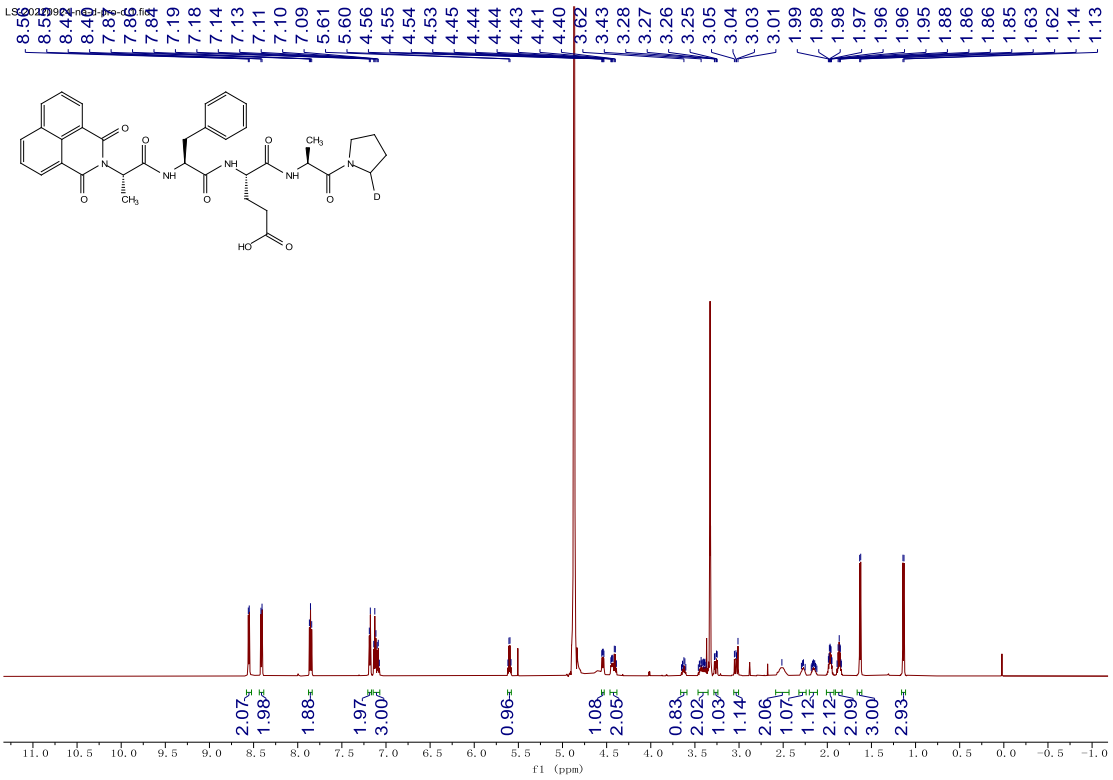
^{13}C NMR spectrum for compound **2x**



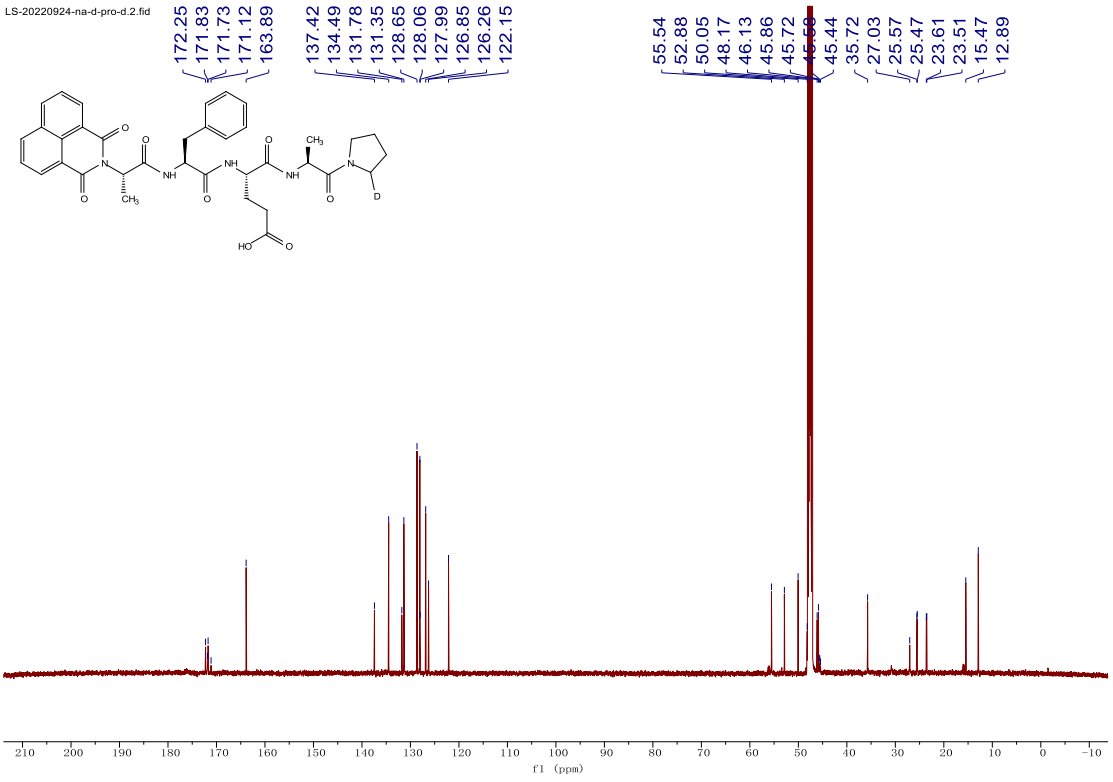
^{1}H NMR spectrum for compound **2y**



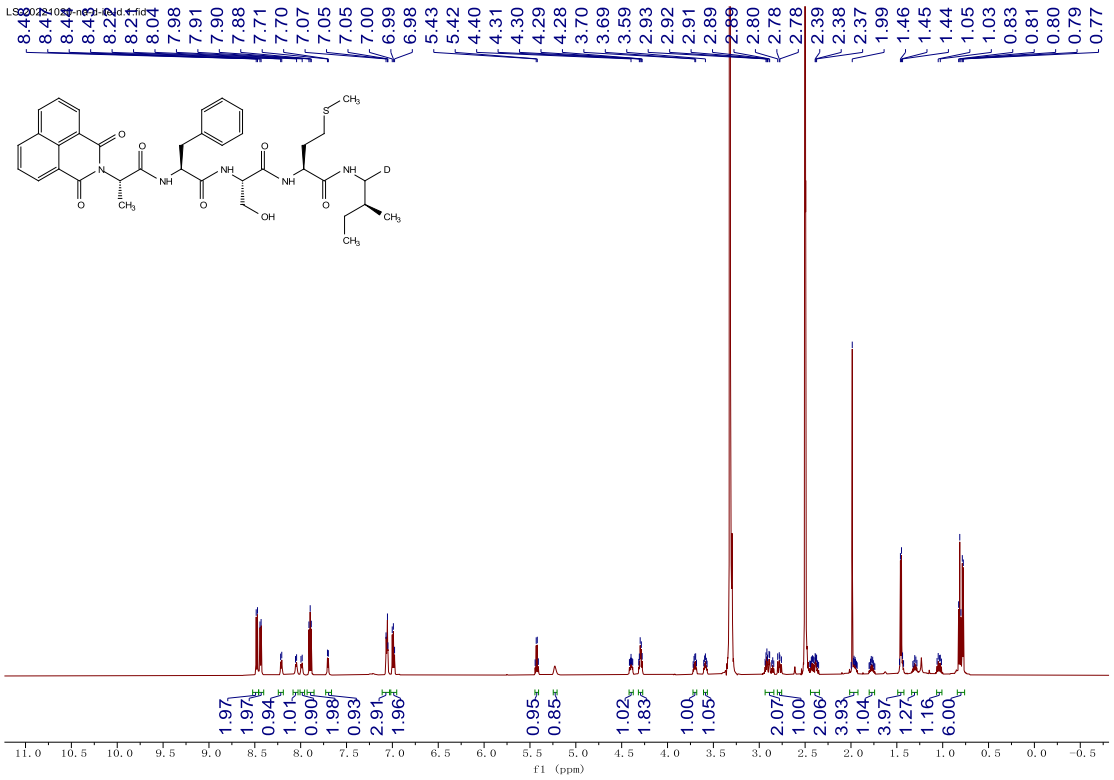
^{13}C NMR spectrum for compound **2y**



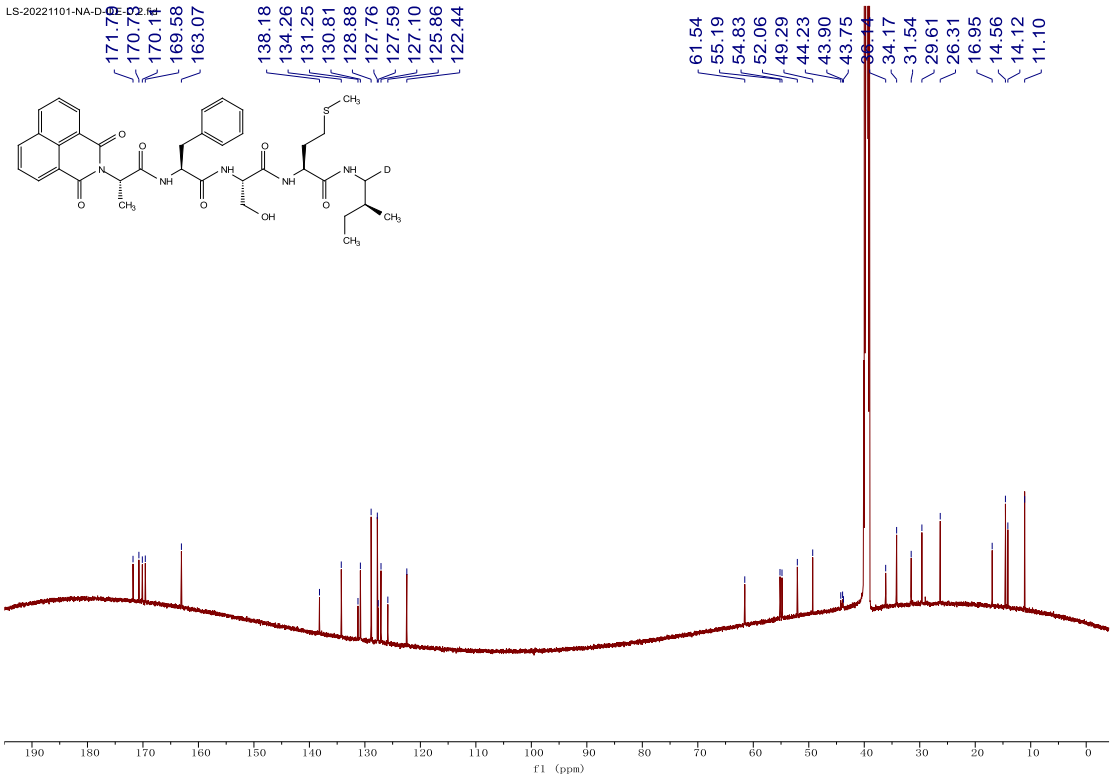
^{1}H NMR spectrum for compound **2z**



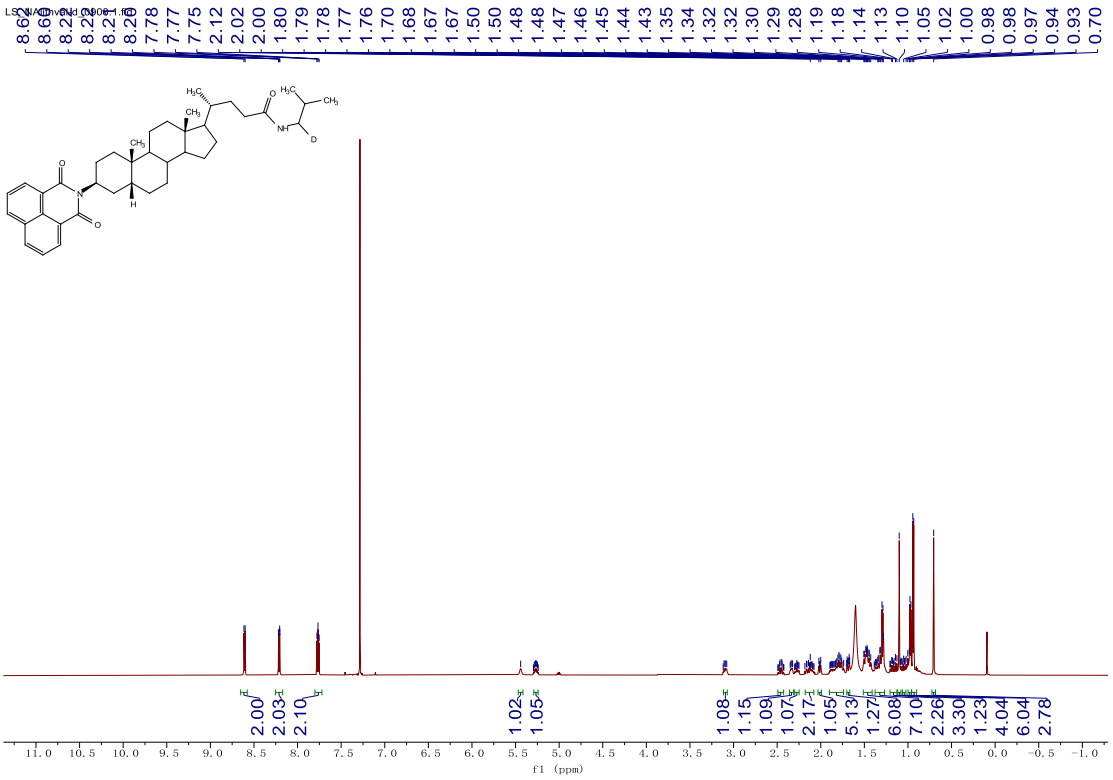
^{13}C NMR spectrum for compound **2z**



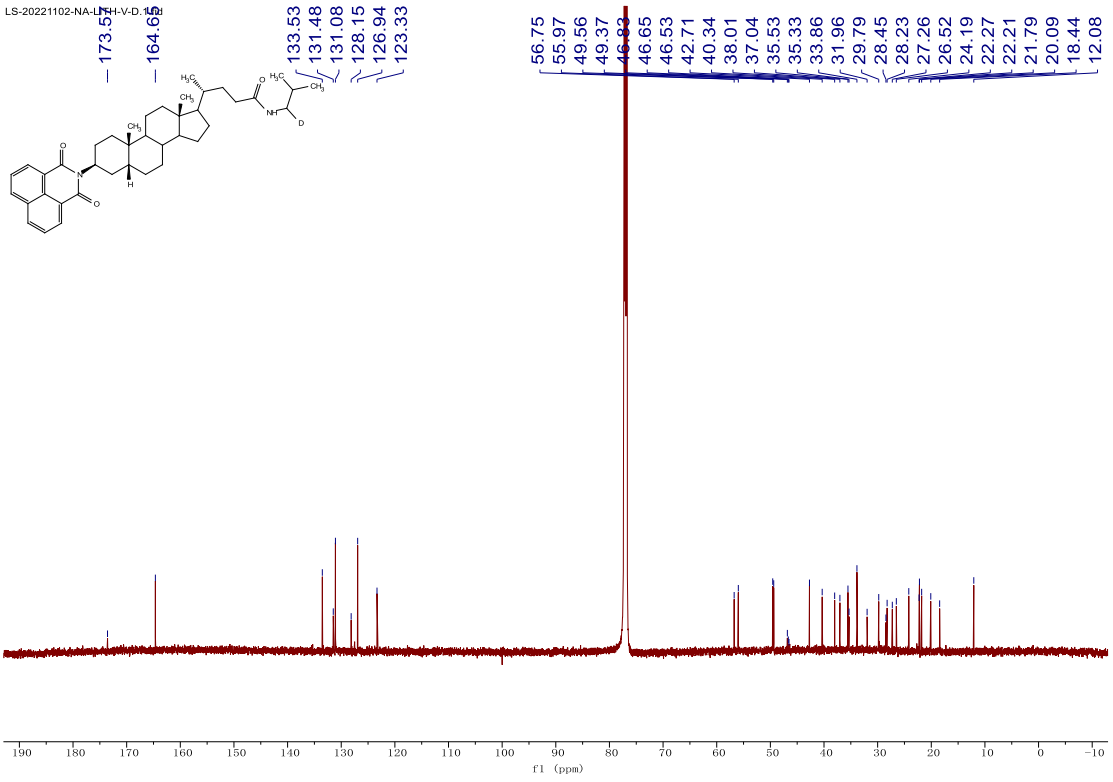
^{1}H NMR spectrum for compound **2aa**



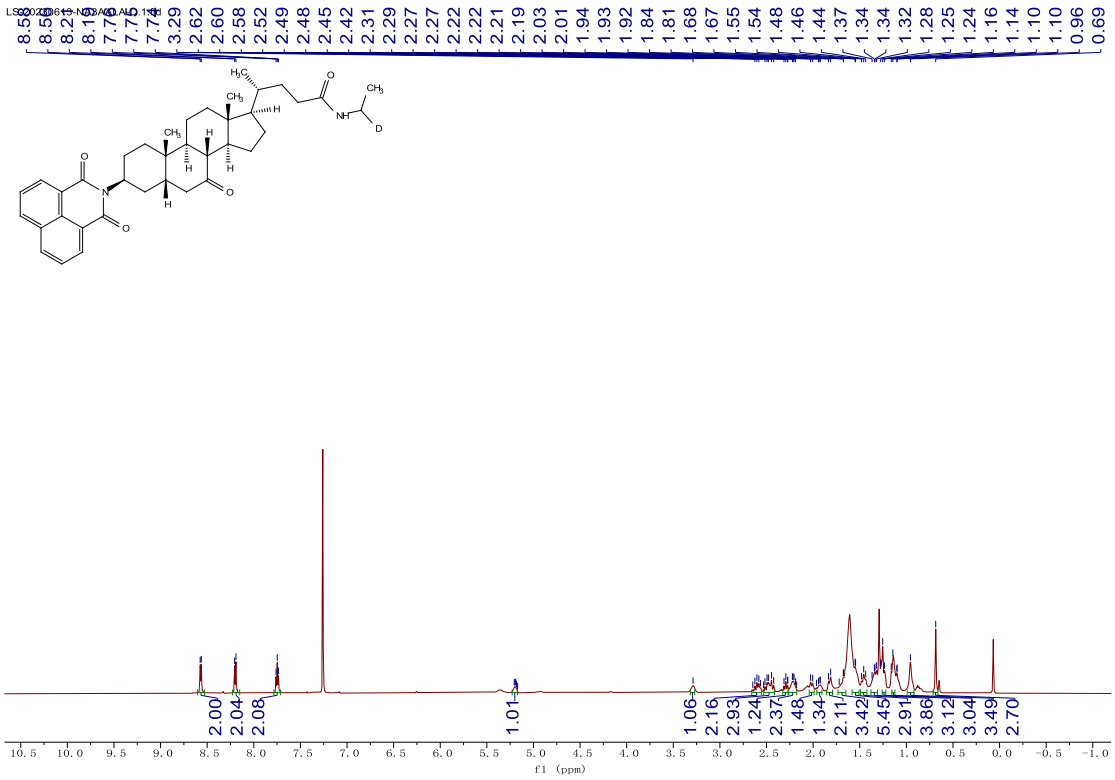
^{13}C NMR spectrum for compound **2aa**



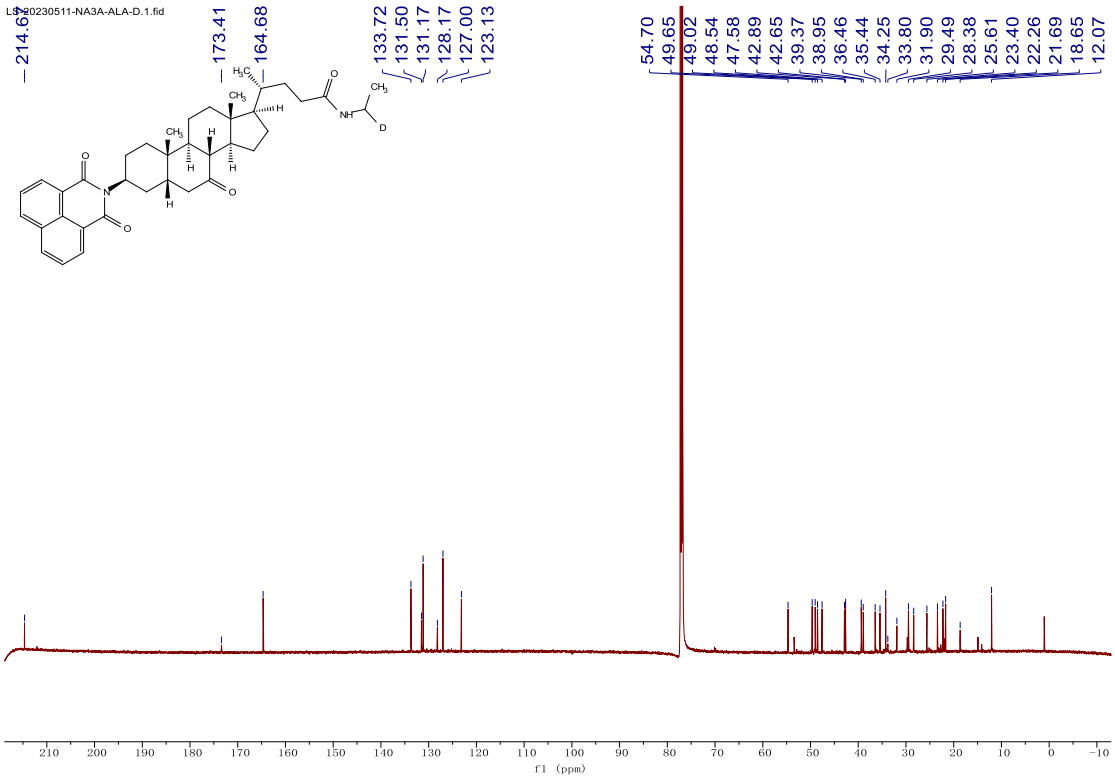
^{1}H NMR spectrum for compound **2bb**



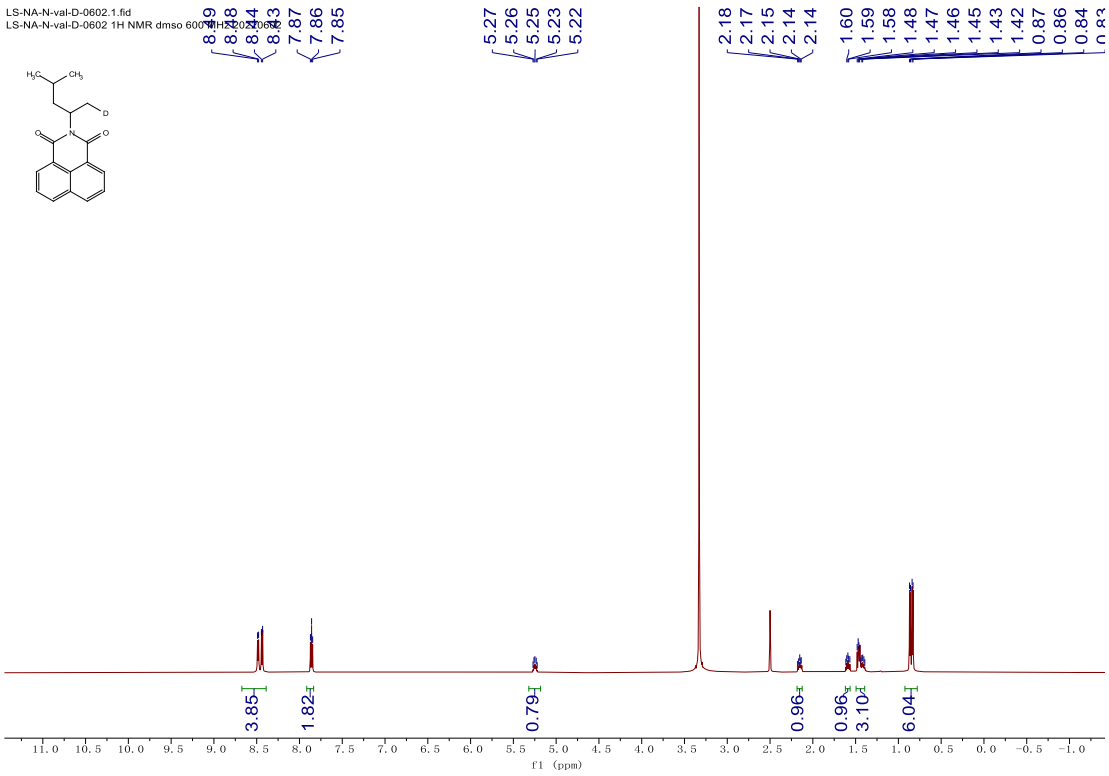
^{13}C NMR spectrum for compound **2bb**



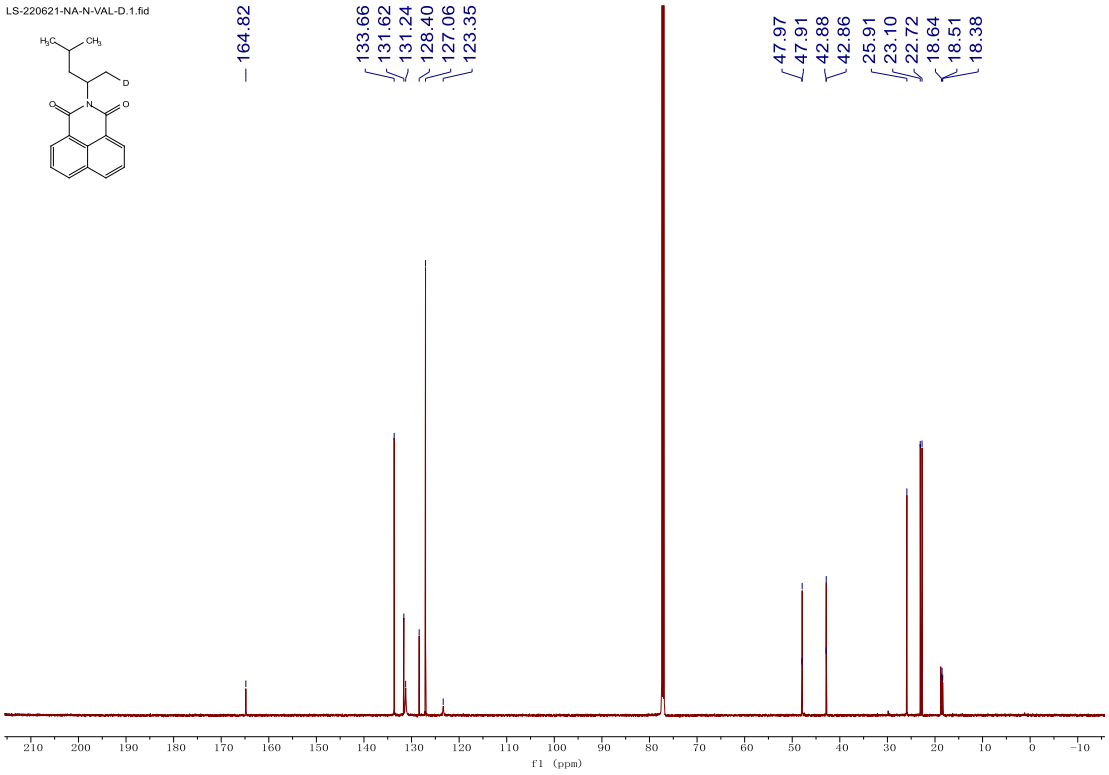
^{1}H NMR spectrum for compound **2cc**



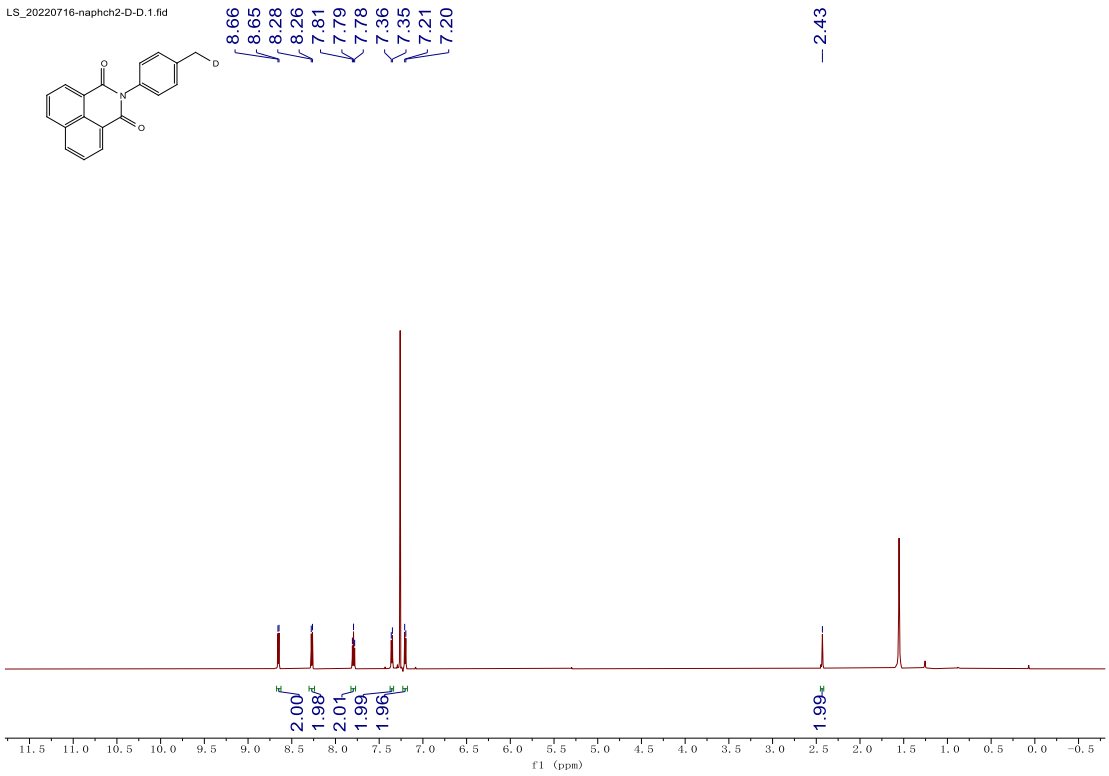
^{13}C NMR spectrum for compound **2cc**



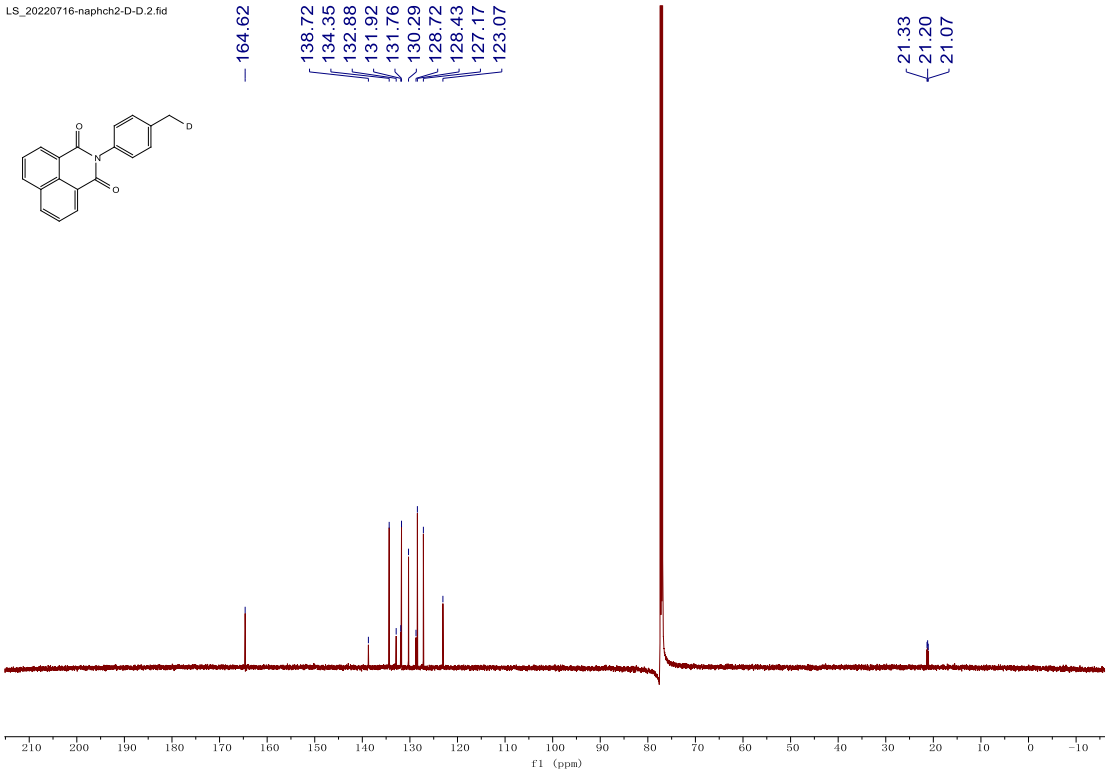
^{1}H NMR spectrum for compound **4a**



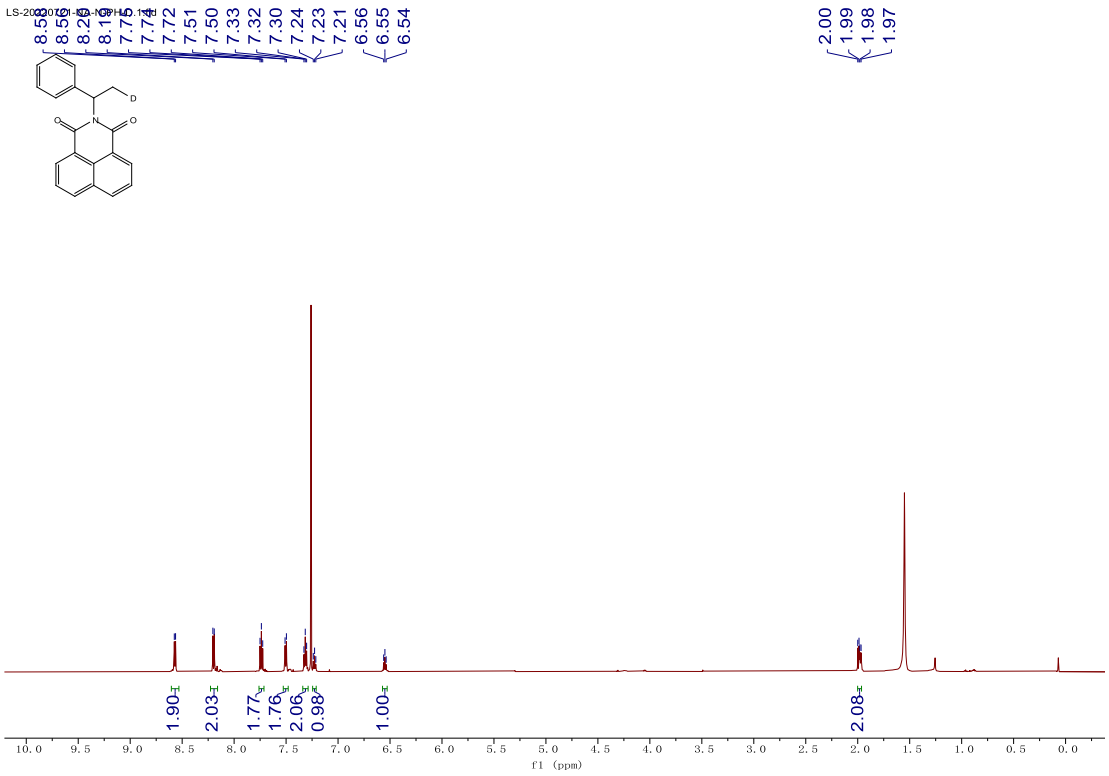
^{13}C NMR spectrum for compound **4a**



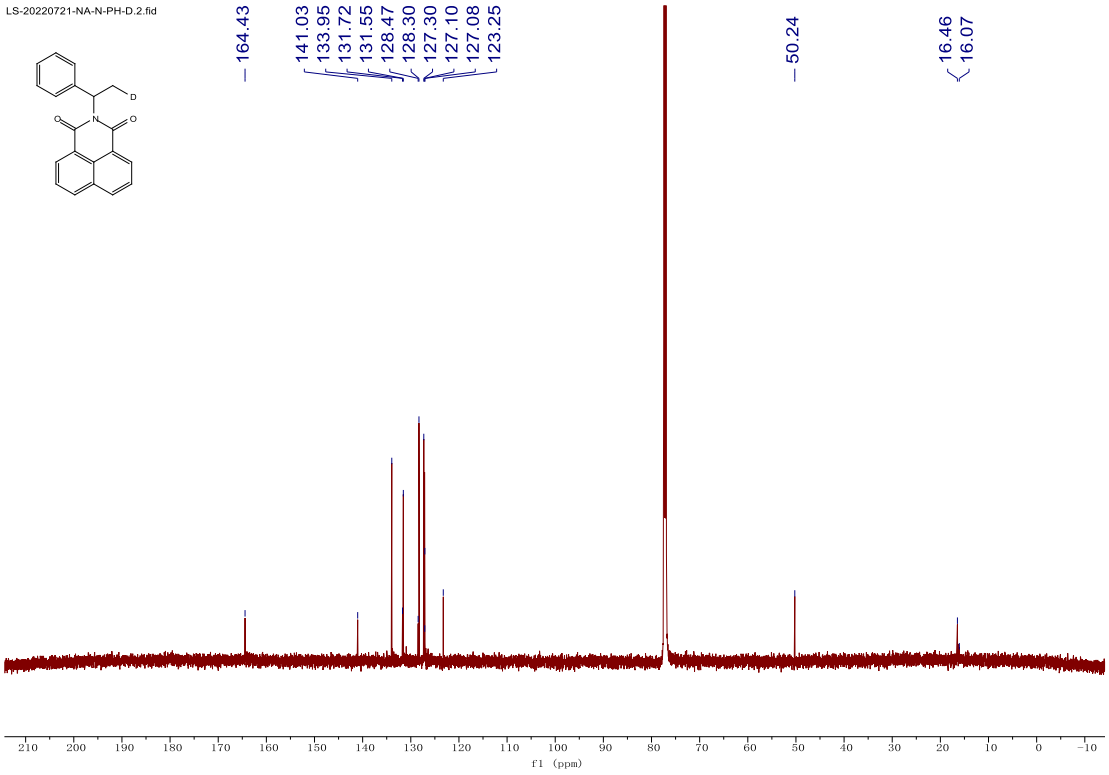
^{1}H NMR spectrum for compound **4b**



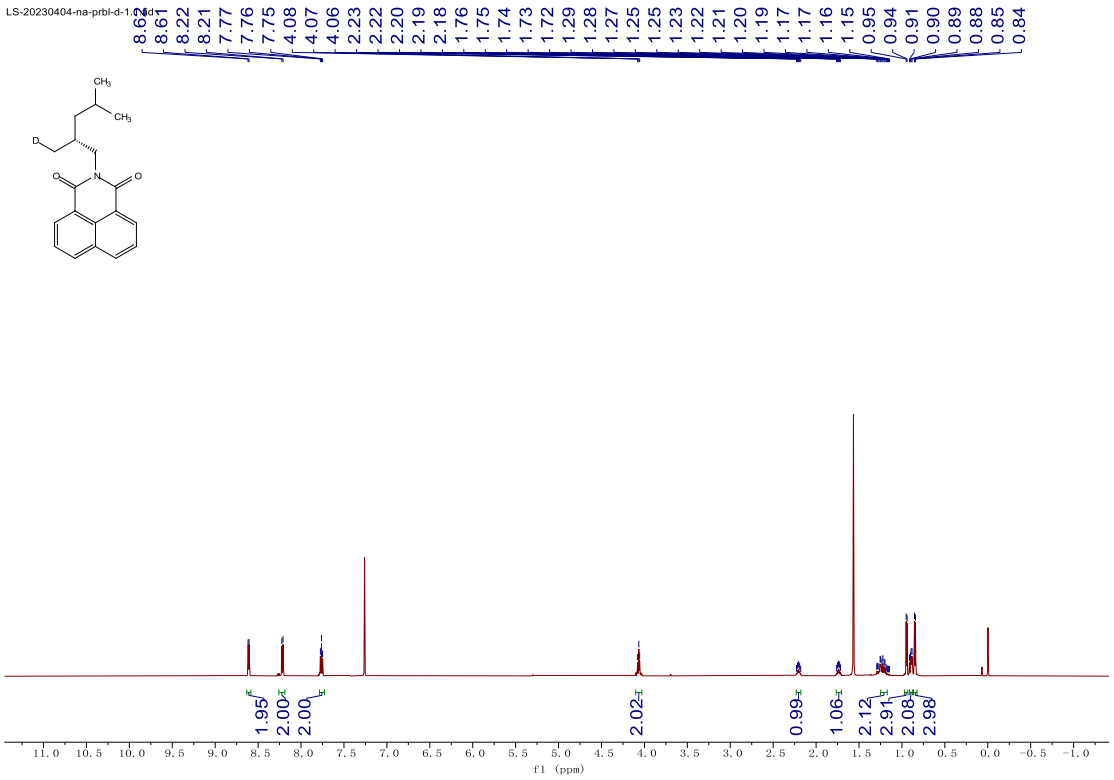
^{13}C NMR spectrum for compound **4b**



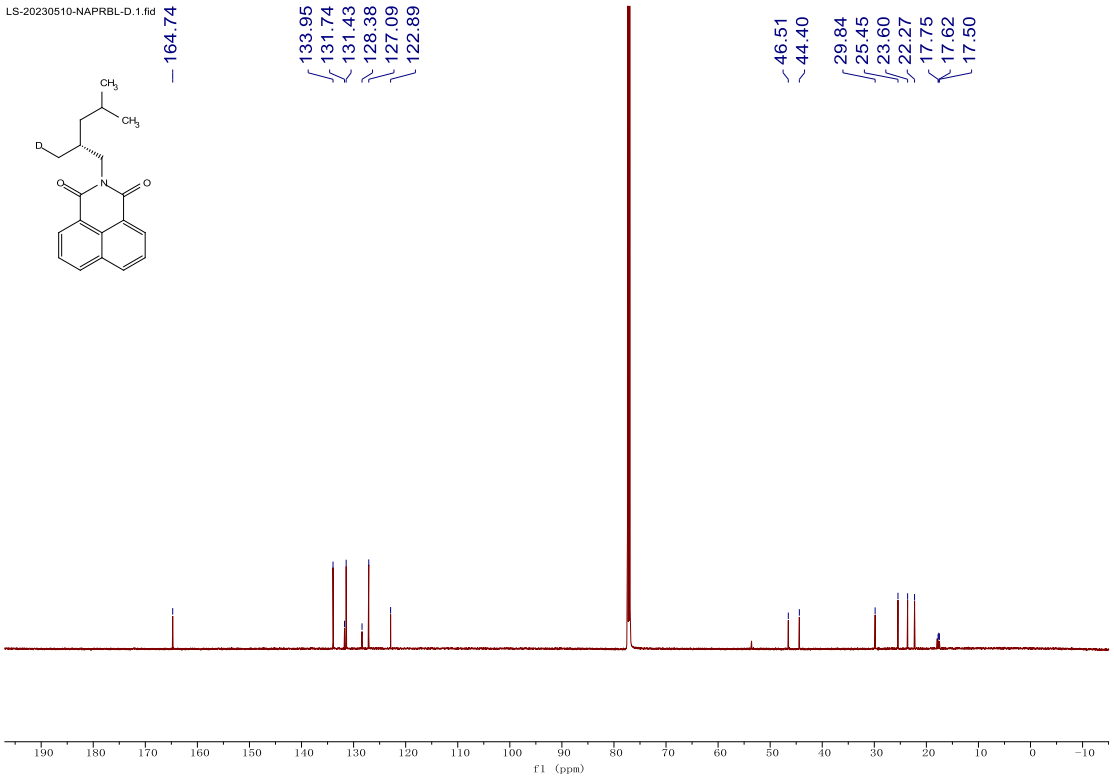
^{1}H NMR spectrum for compound **4c**



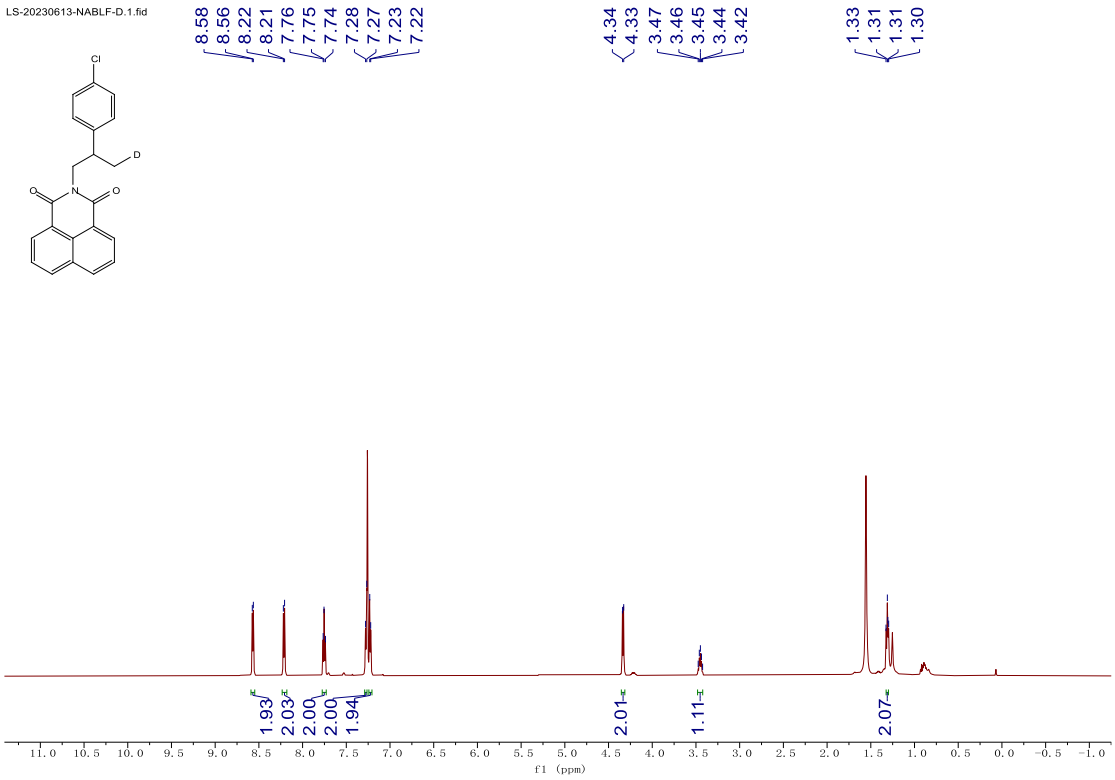
^{13}C NMR spectrum for compound **4c**



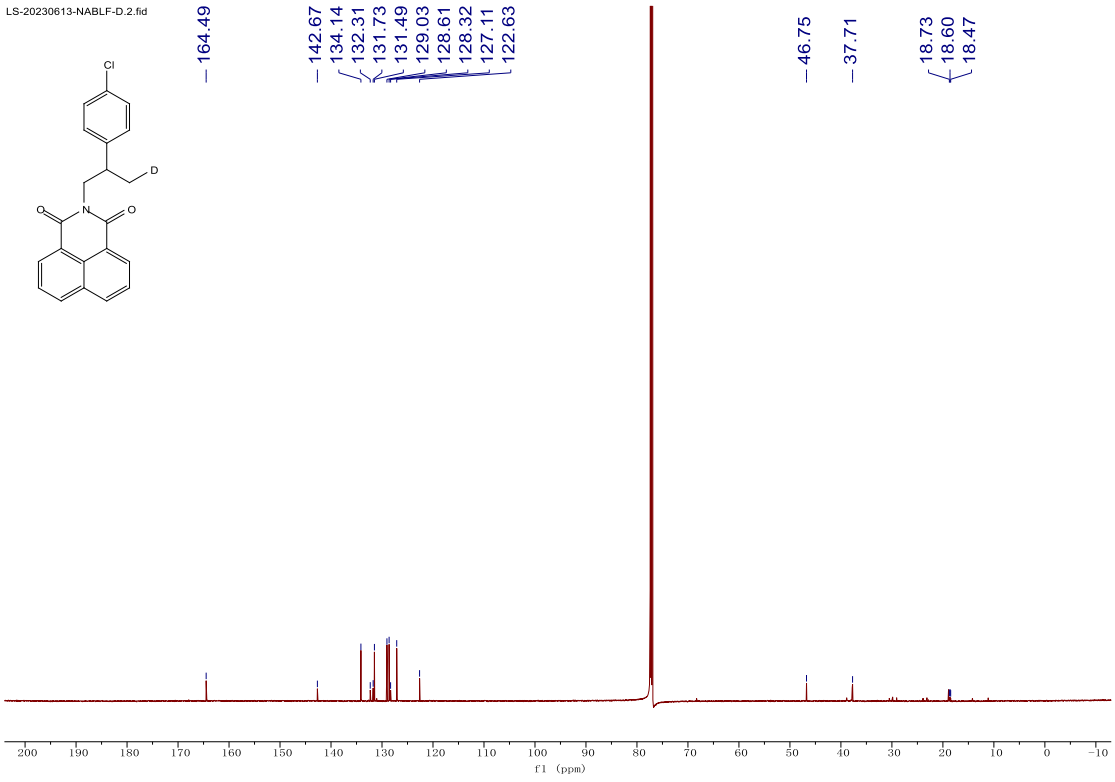
^{1}H NMR spectrum for compound **4d**



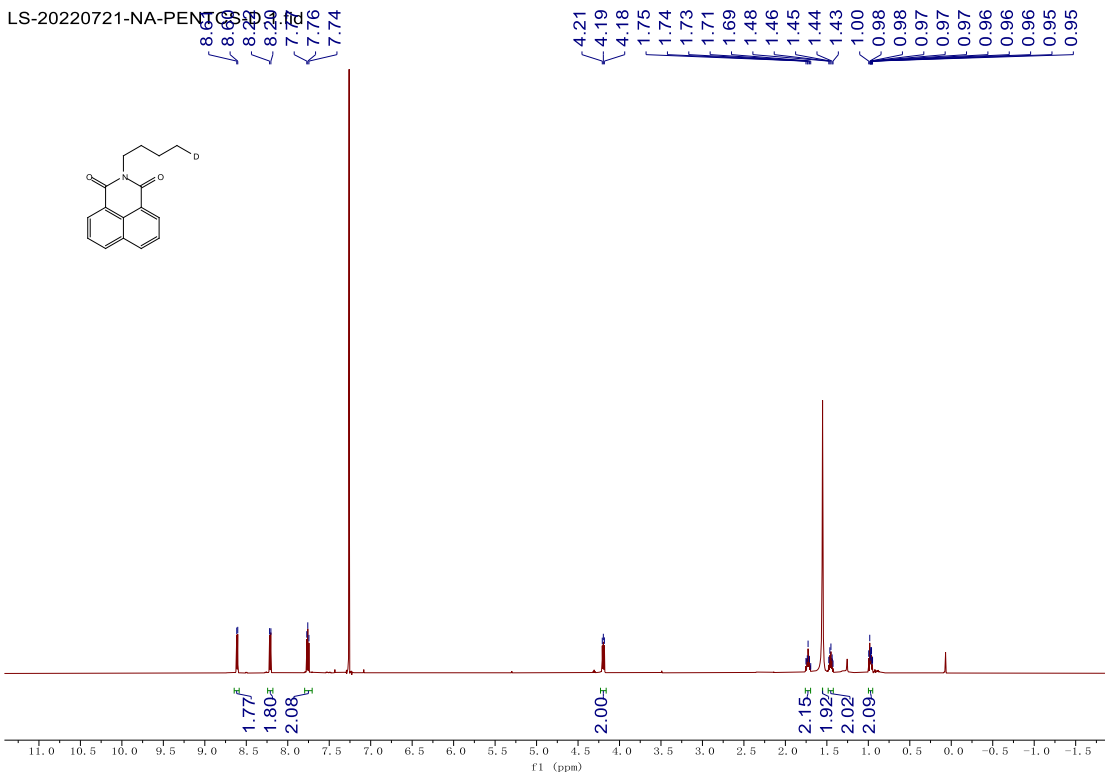
^{13}C NMR spectrum for compound **4d**



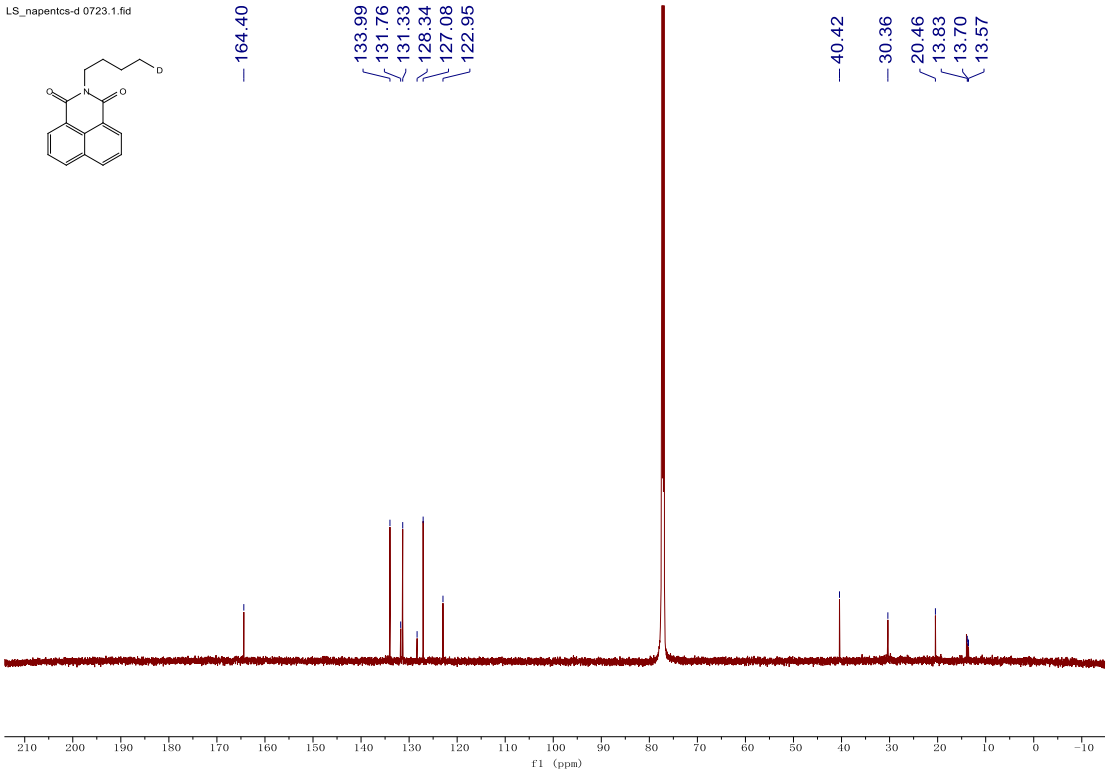
^{1}H NMR spectrum for compound **4e**



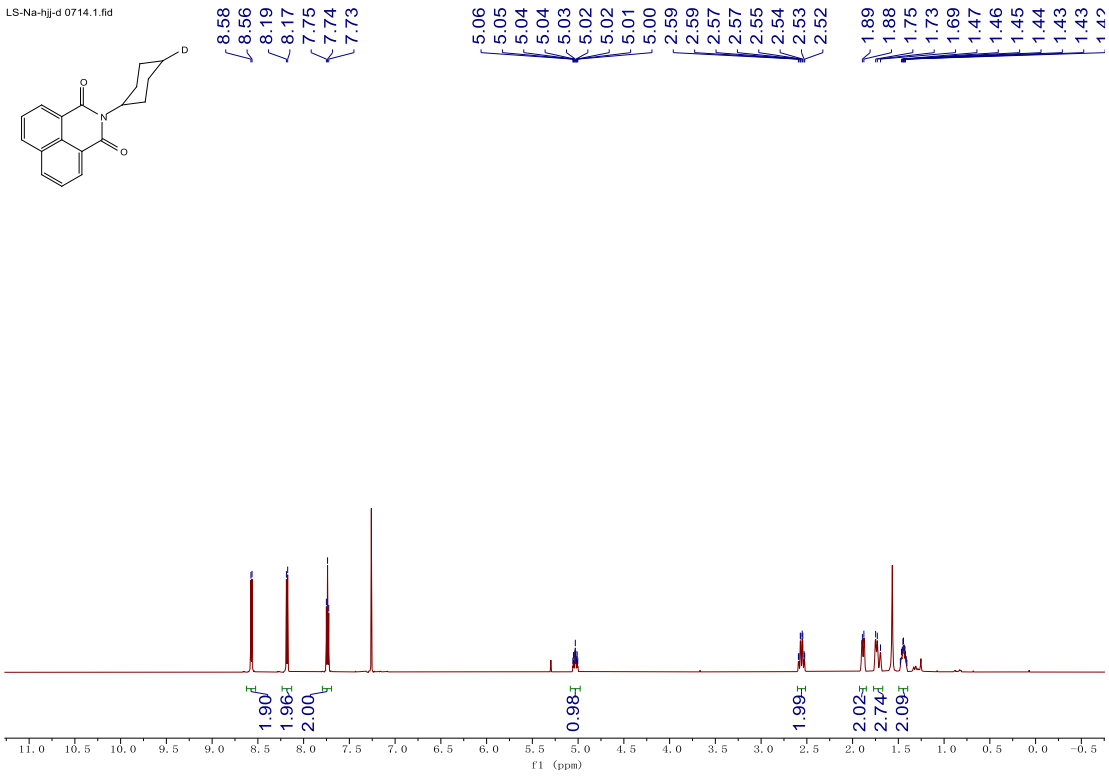
^{13}C NMR spectrum for compound **4e**



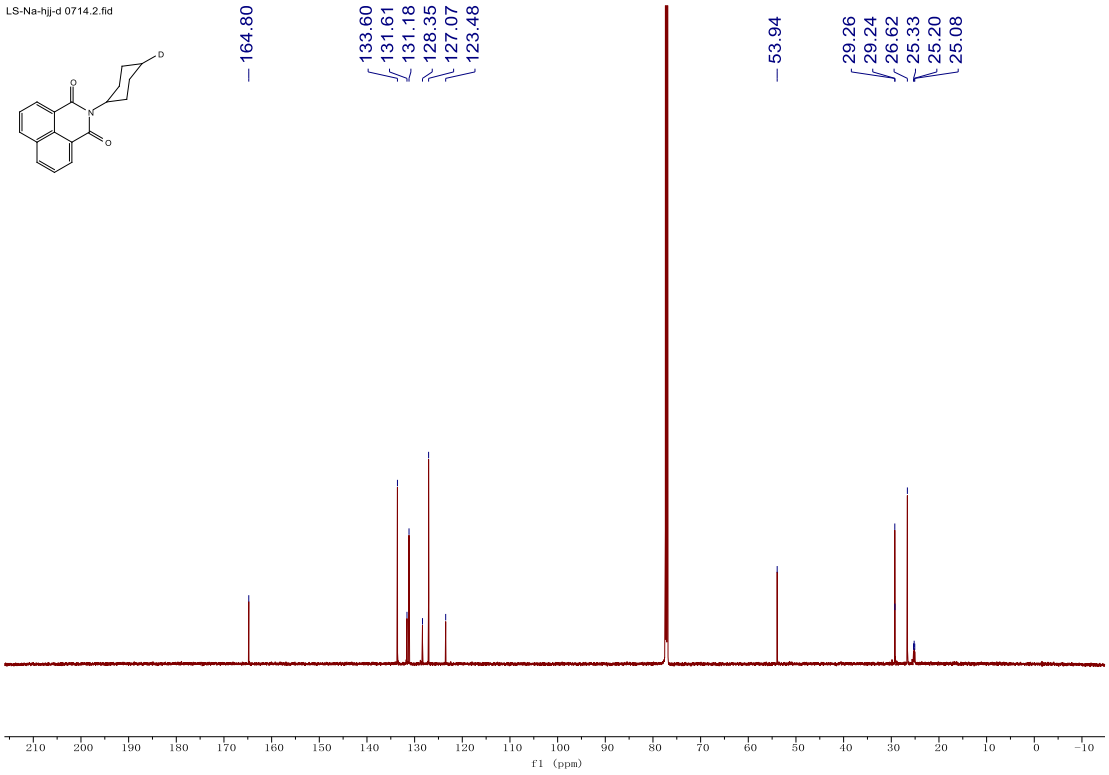
^{1}H NMR spectrum for compound **4f**



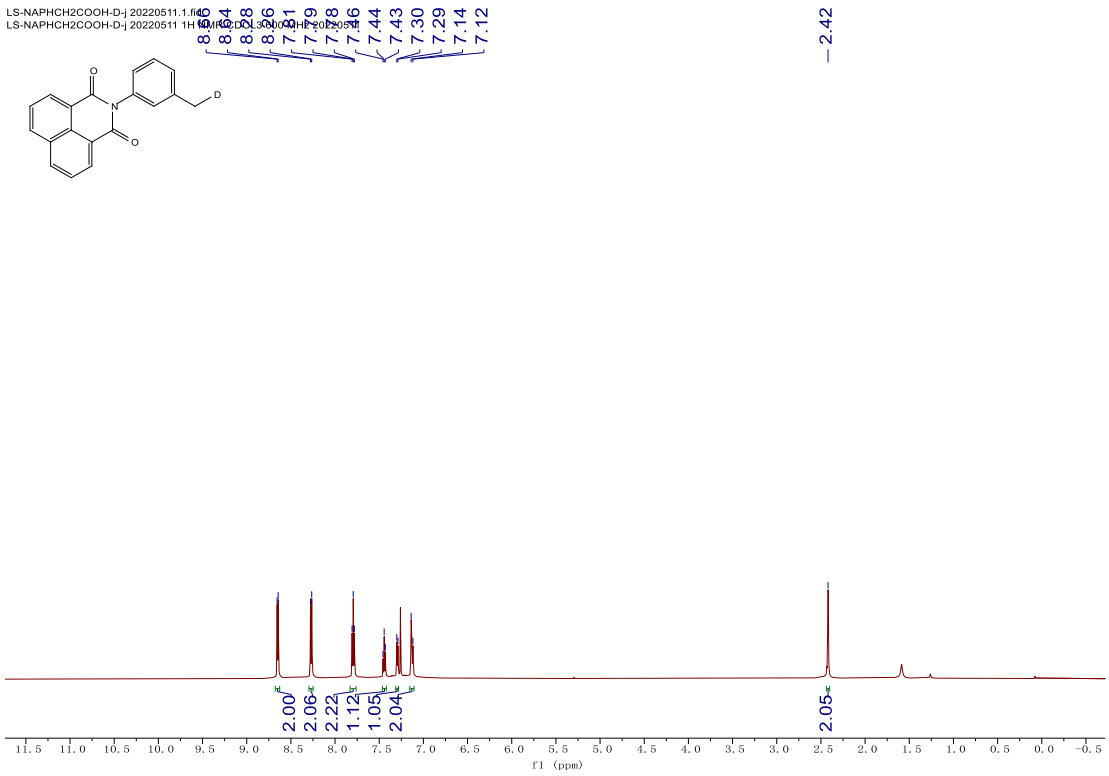
^{13}C NMR spectrum for compound **4f**



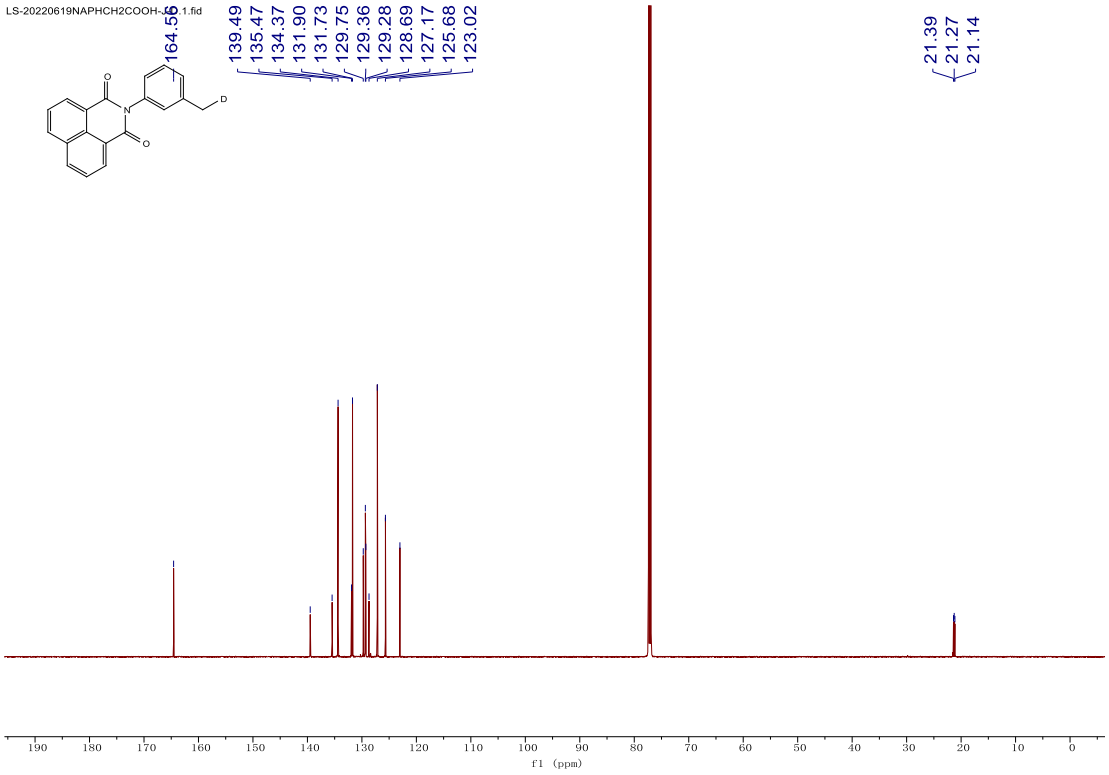
^{1}H NMR spectrum for compound **4g**



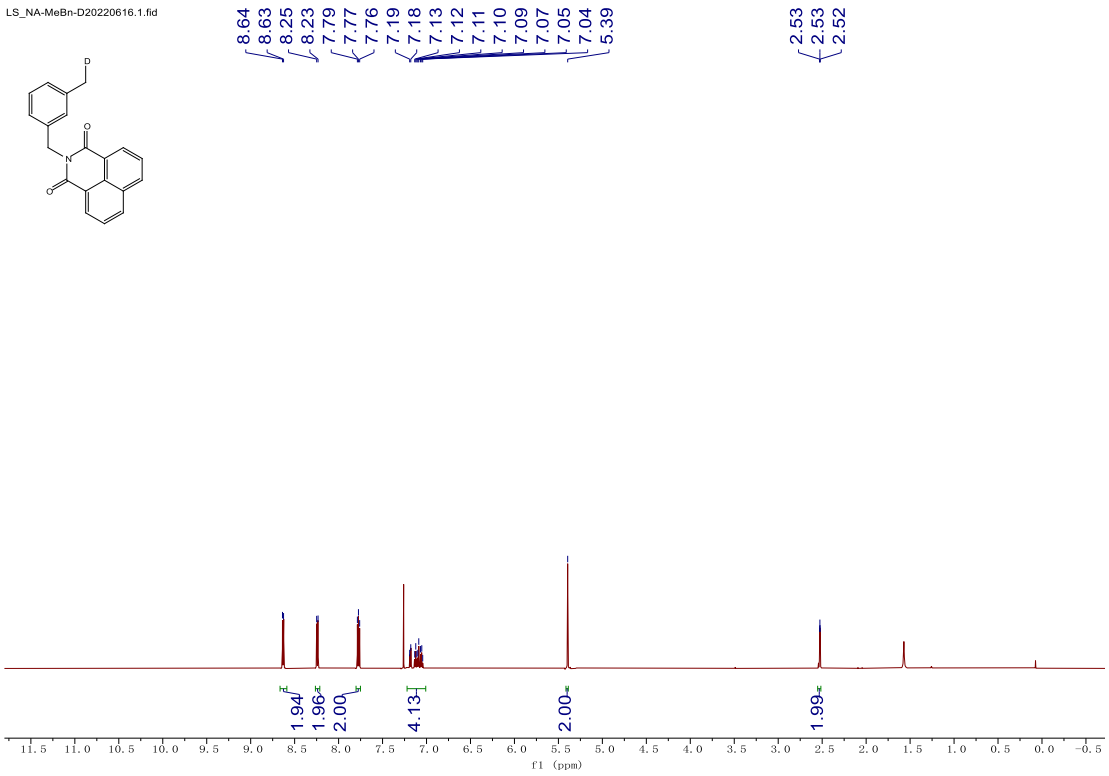
^{13}C NMR spectrum for compound **4g**



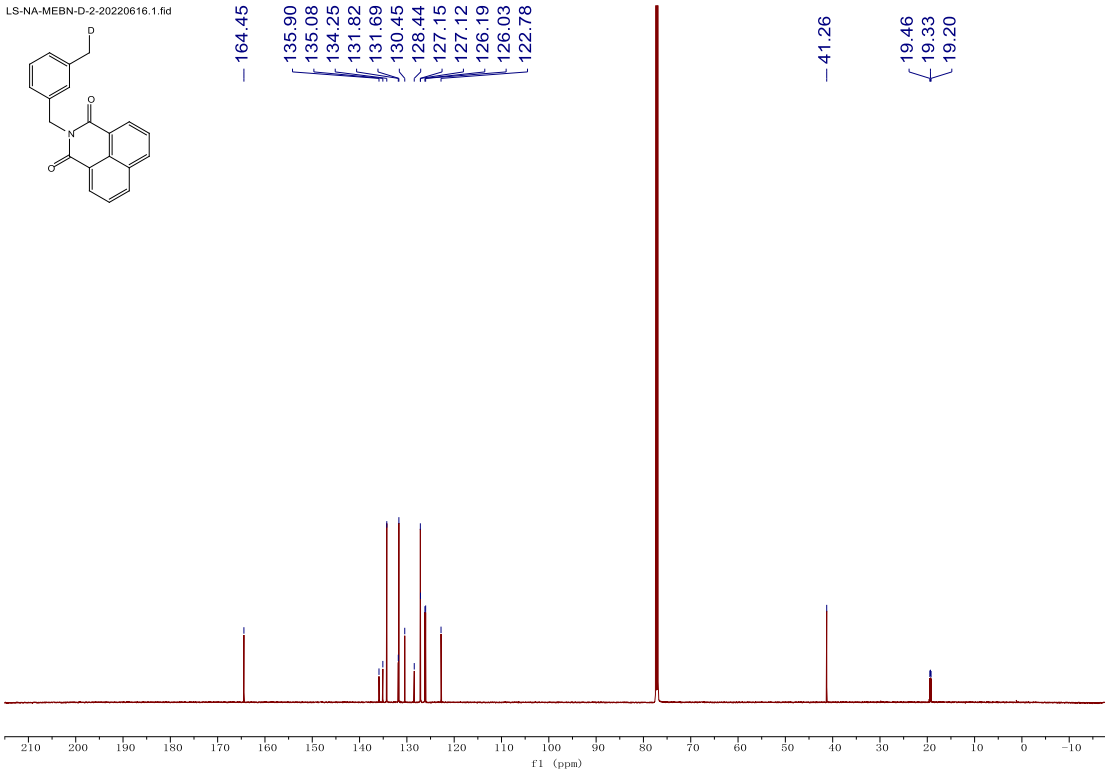
^{1}H NMR spectrum for compound **4h**



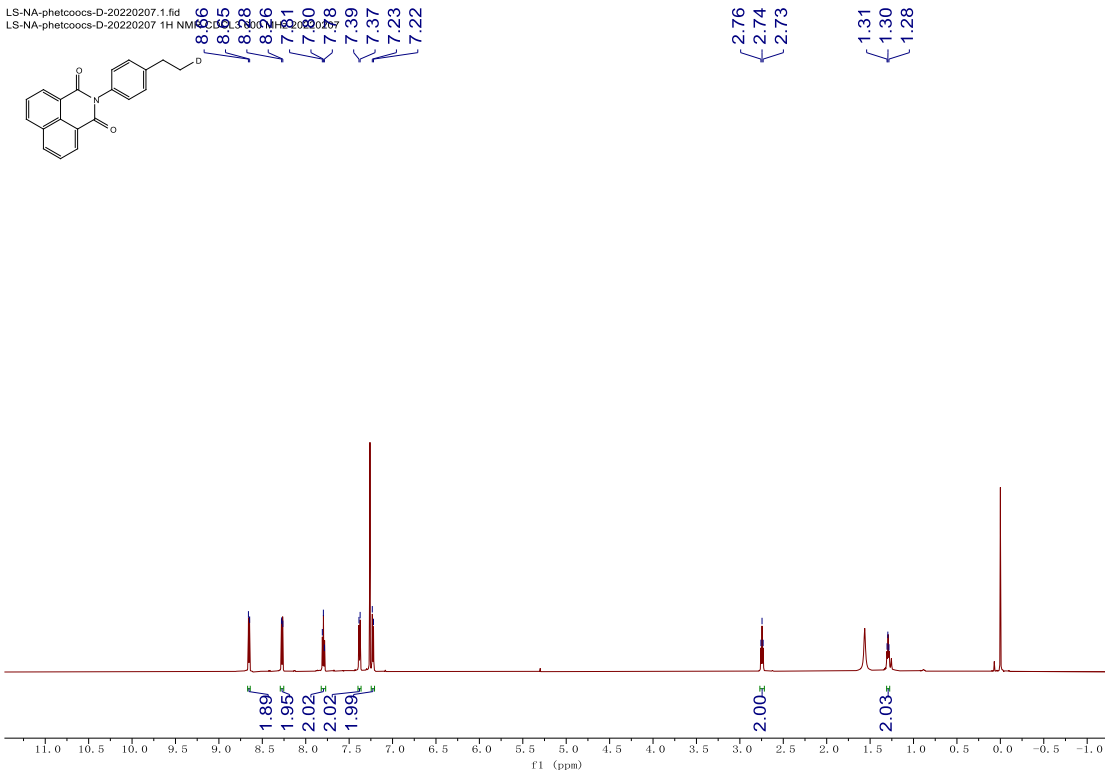
^{13}C NMR spectrum for compound **4h**



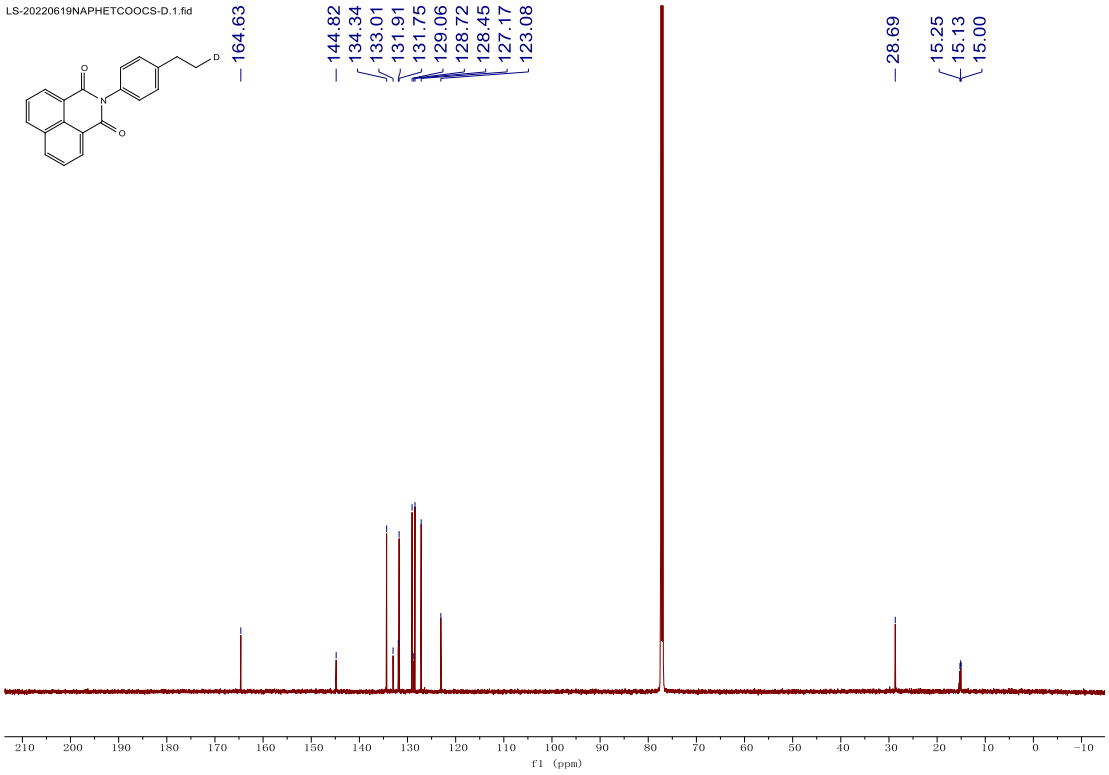
^{1}H NMR spectrum for compound **4i**



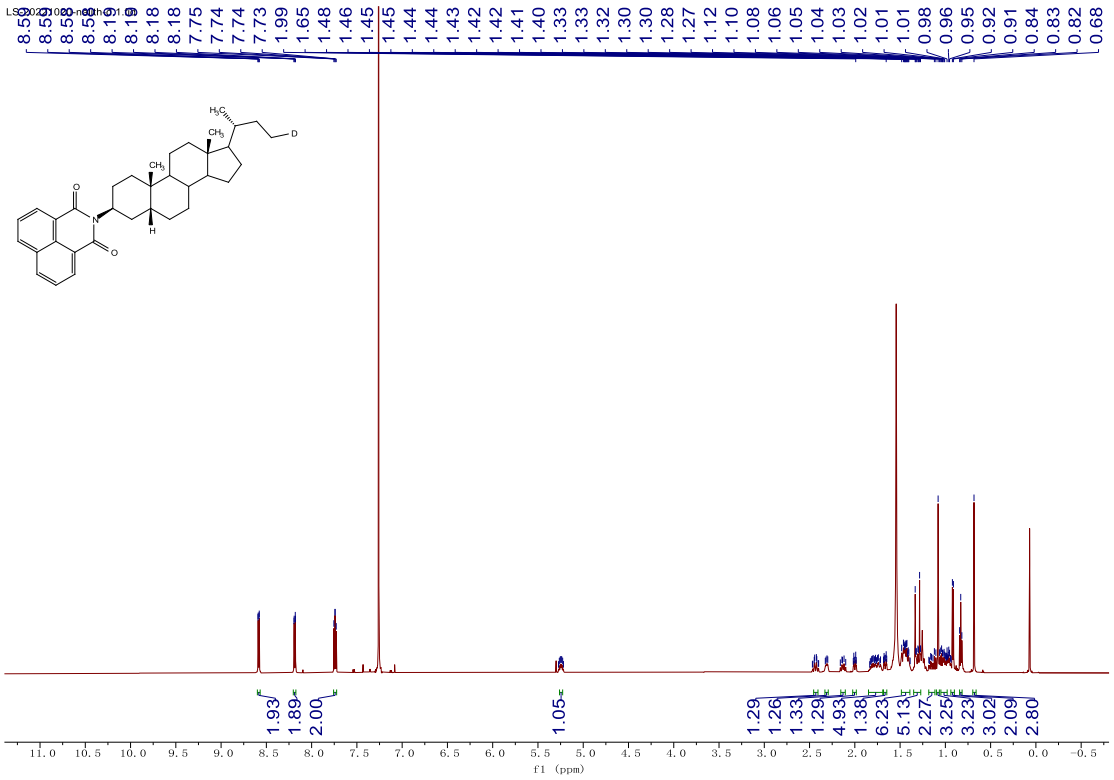
^{13}C NMR spectrum for compound **4i**



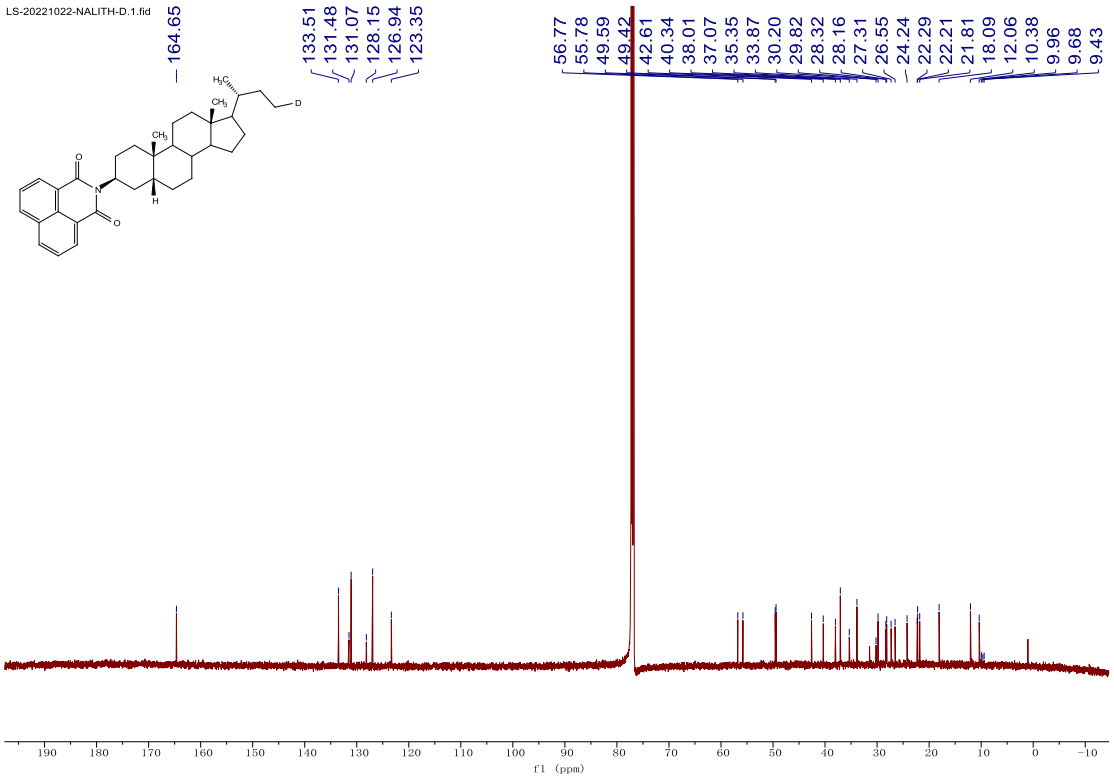
^{1}H NMR spectrum for compound **4j**



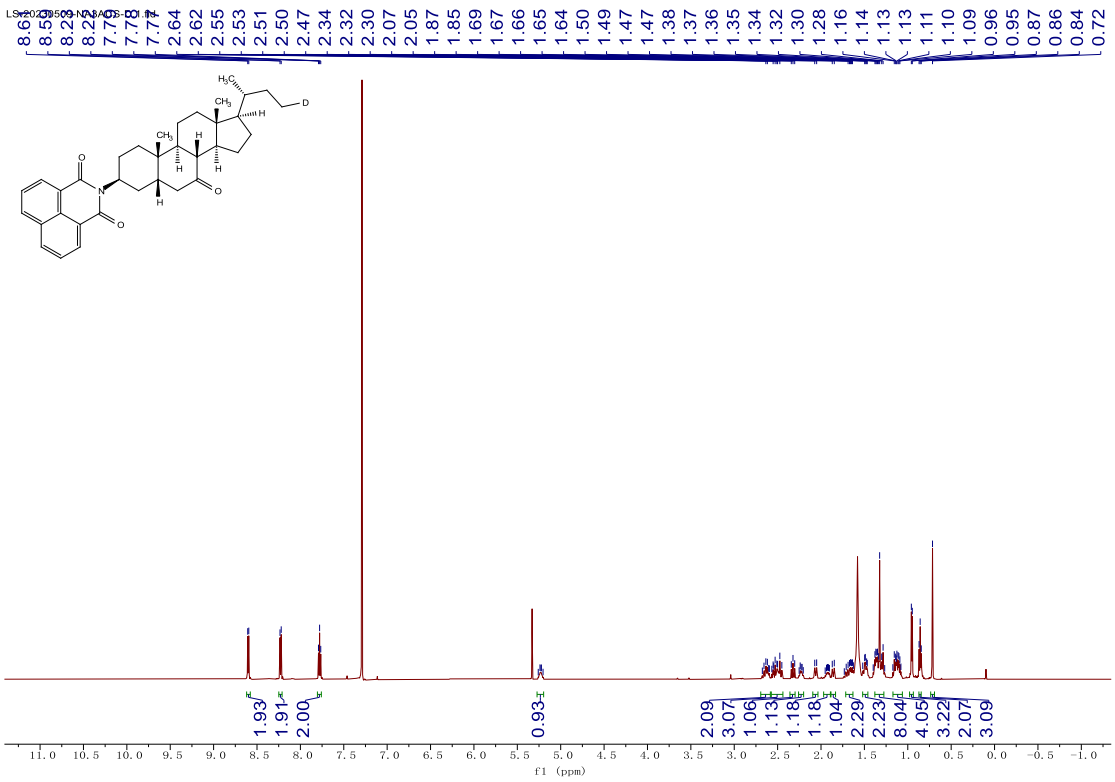
^{13}C NMR spectrum for compound **4j**



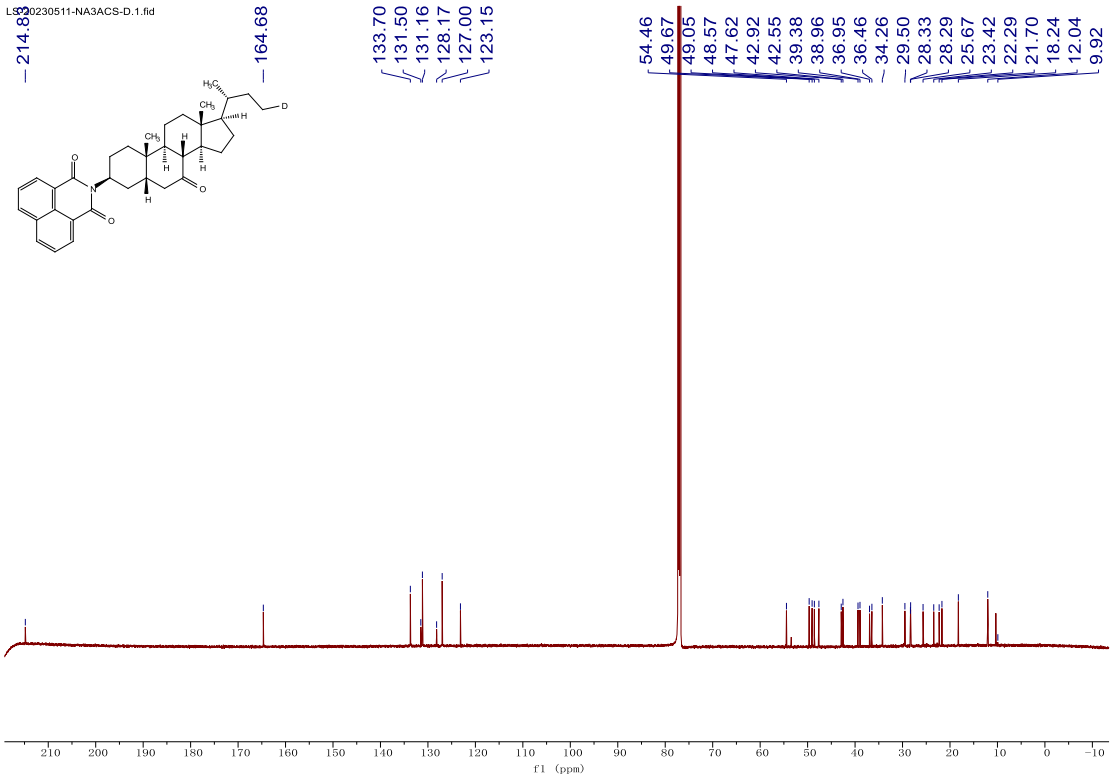
^{1}H NMR spectrum for compound **4k**



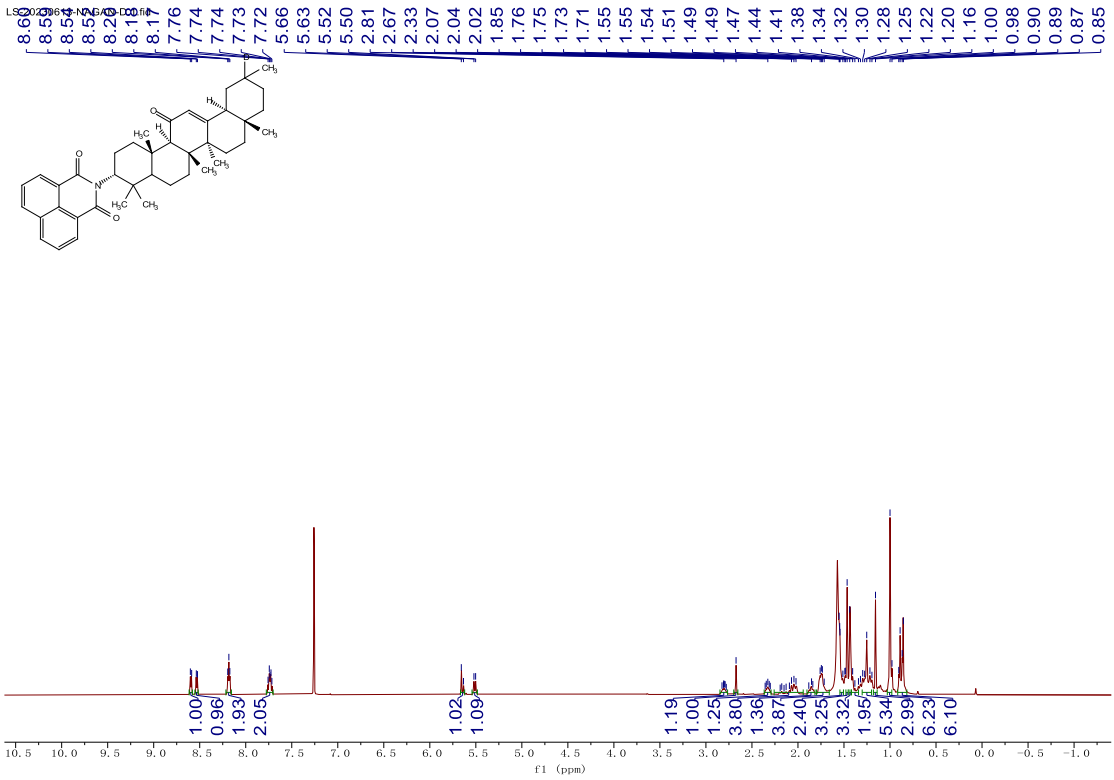
^{13}C NMR spectrum for compound **4k**



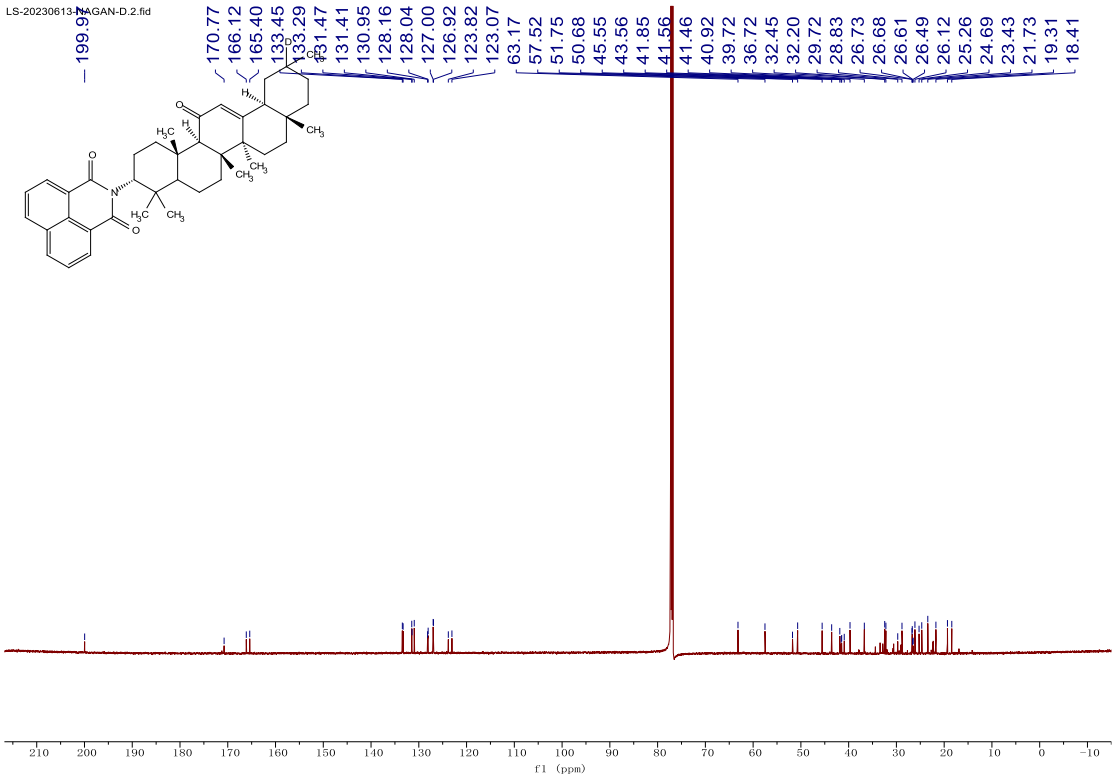
^{1}H NMR spectrum for compound **4l**



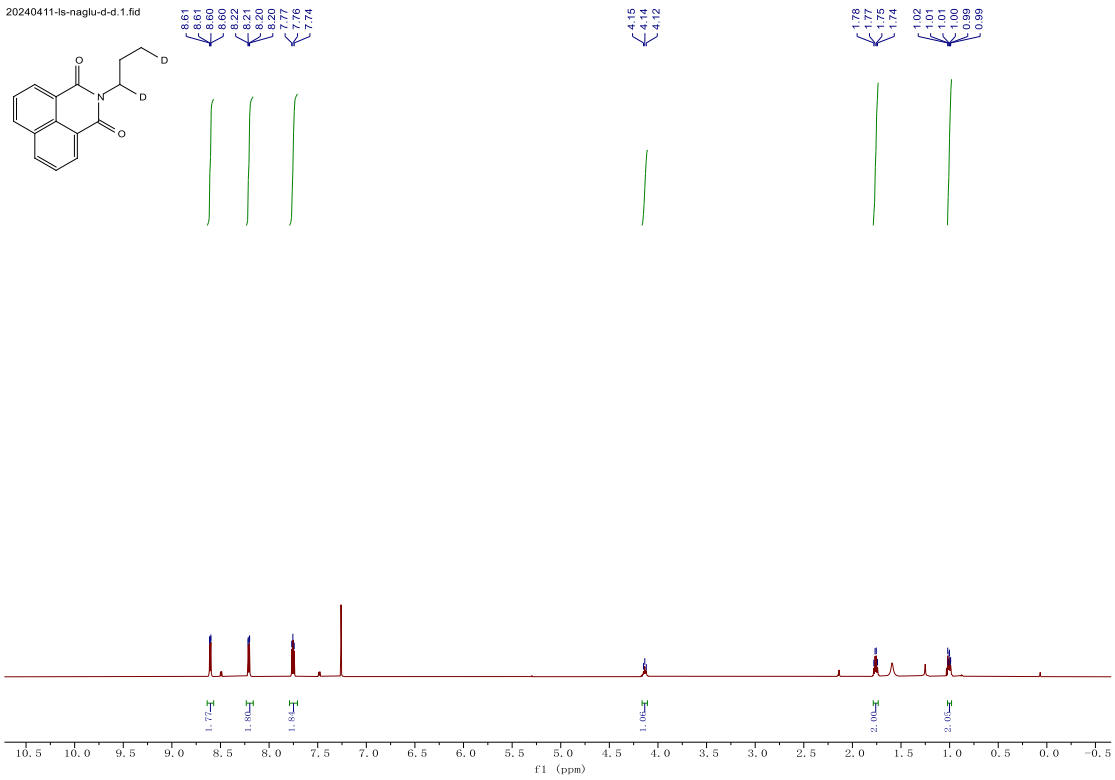
^{13}C NMR spectrum for compound **4l**



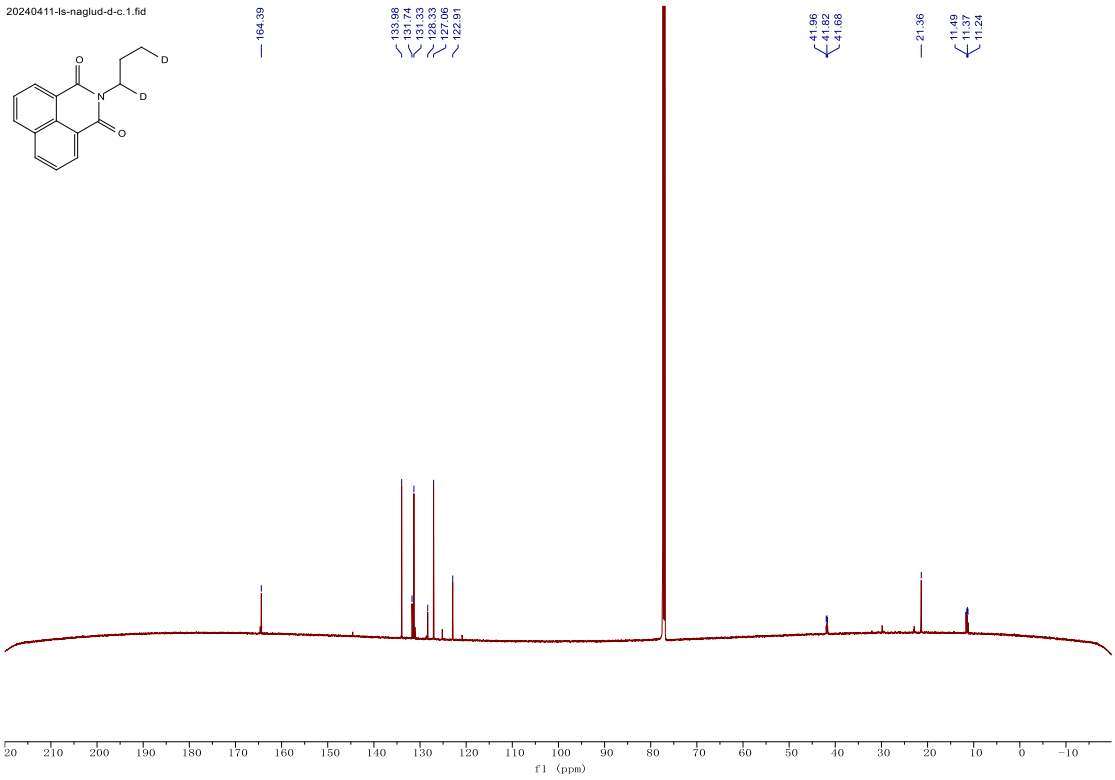
^{1}H NMR spectrum for compound **4m**



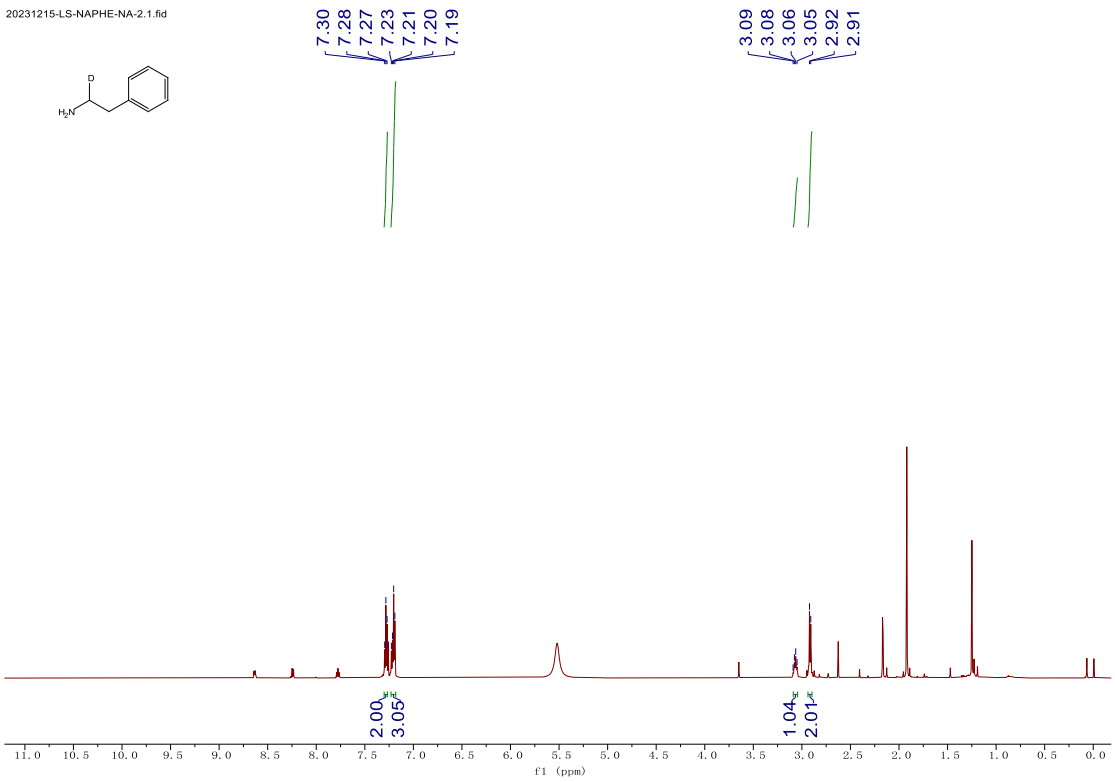
^{13}C NMR spectrum for compound **4m**



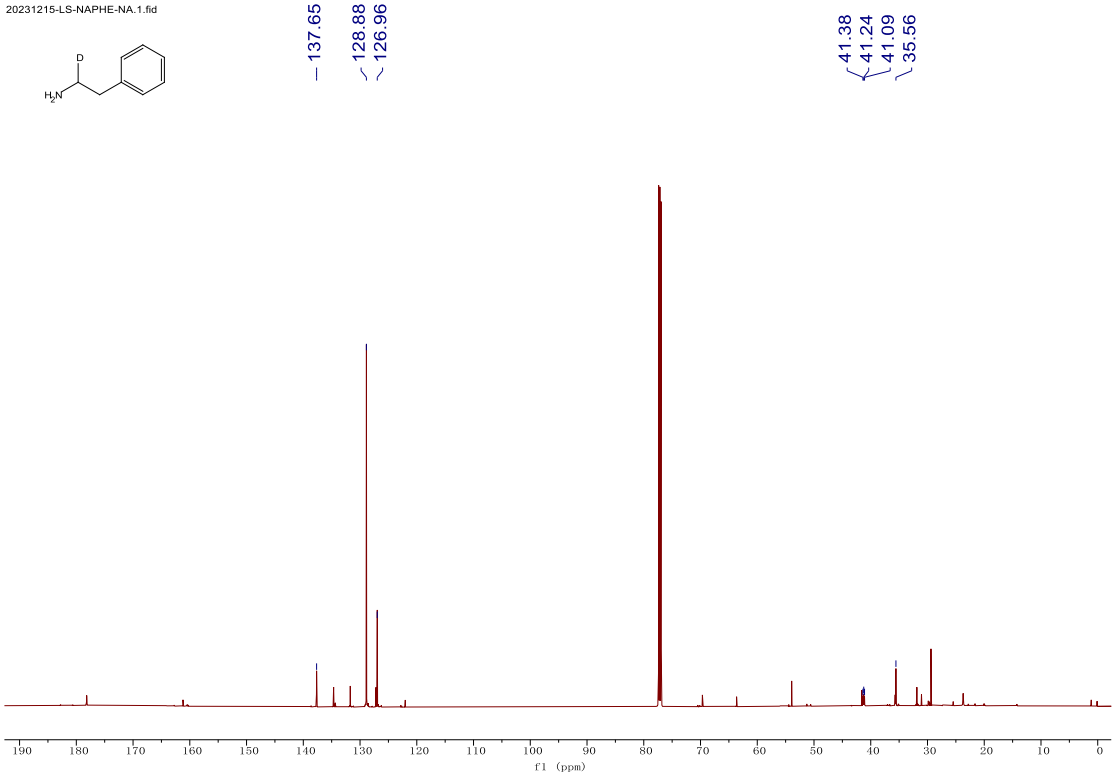
^{1}H NMR spectrum for compound **4v**



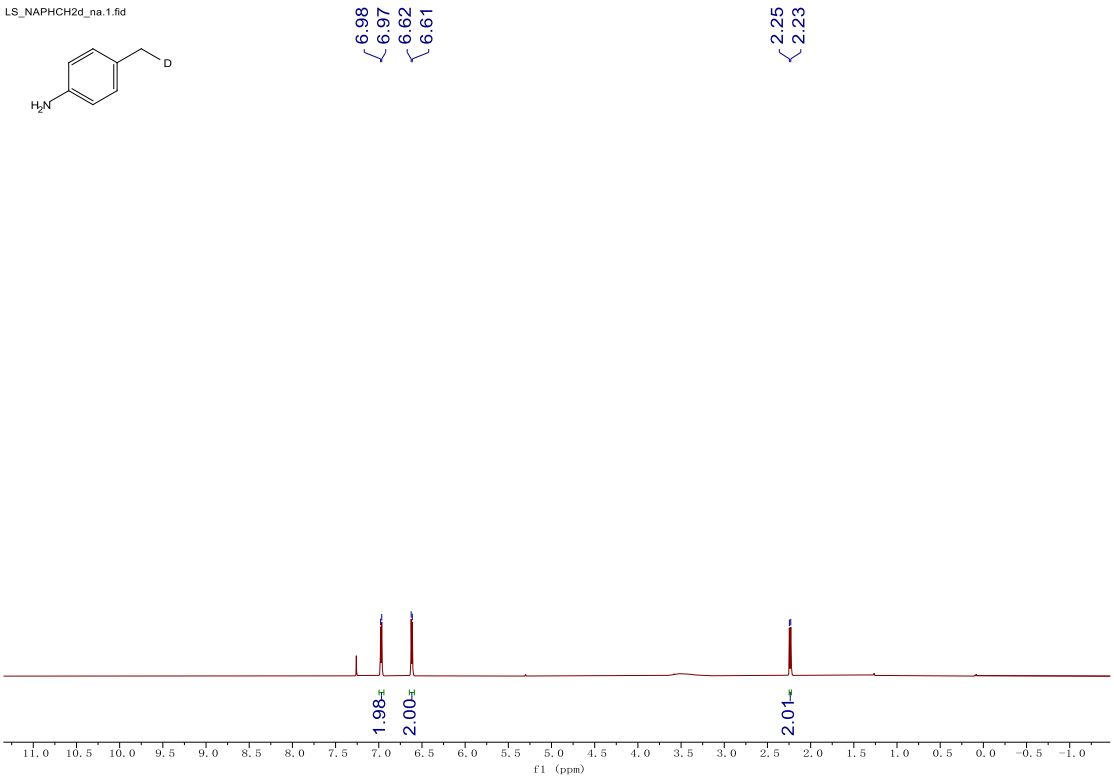
^{13}C NMR spectrum for compound **4v**



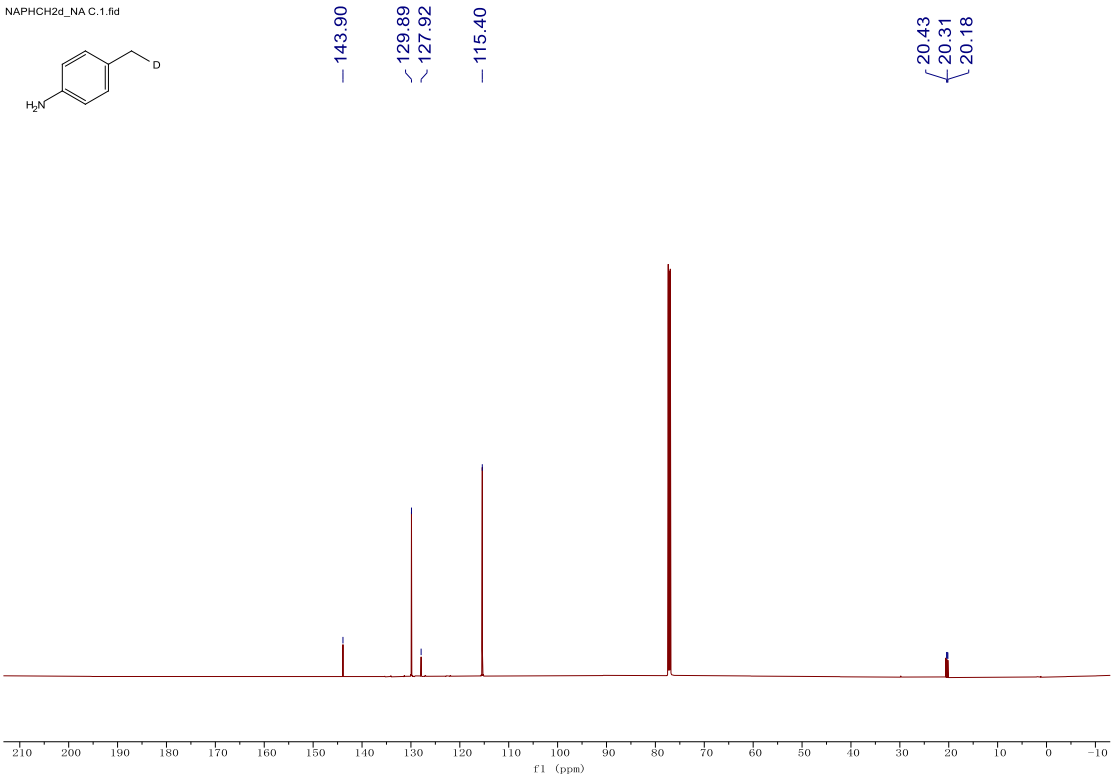
^{1}H NMR spectrum for compound **5a**



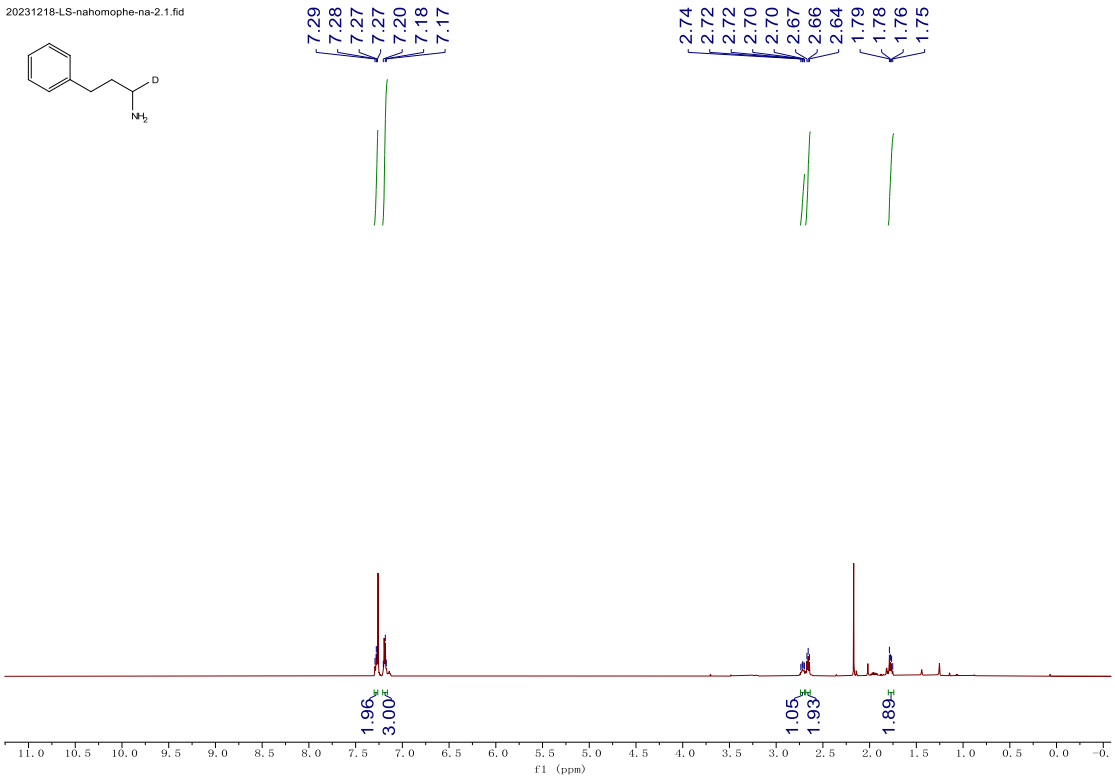
^{13}C NMR spectrum for compound **5a**



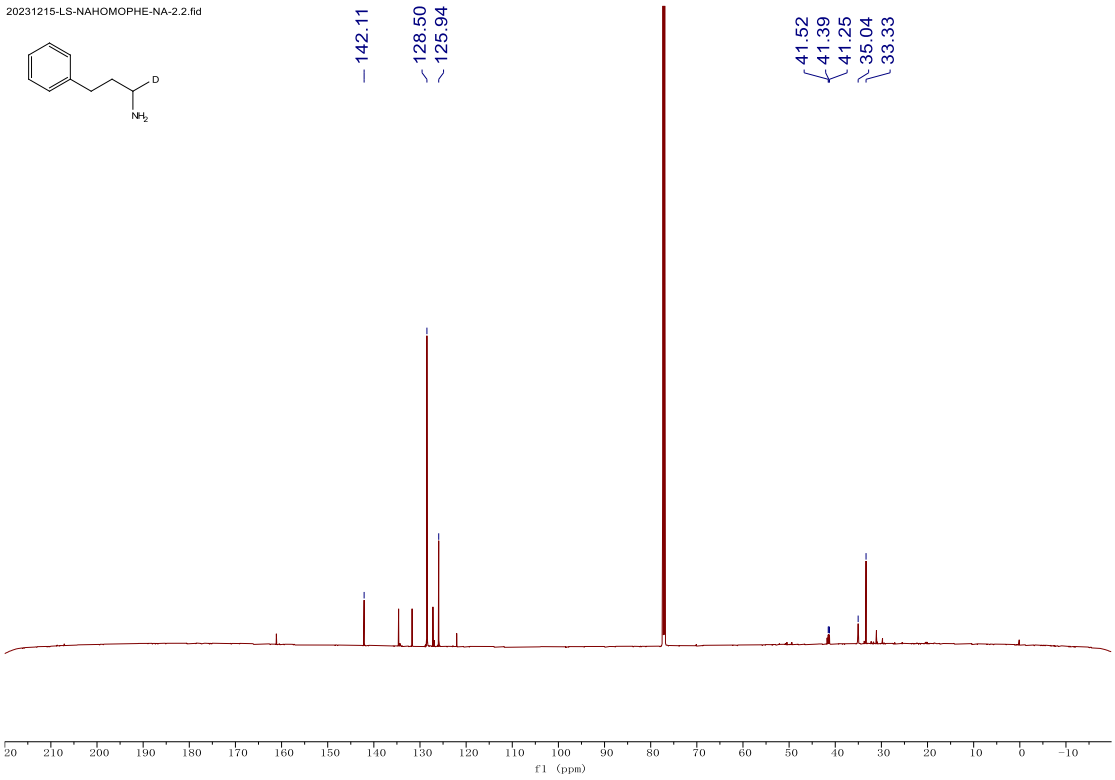
^{1}H NMR spectrum for compound **5b**



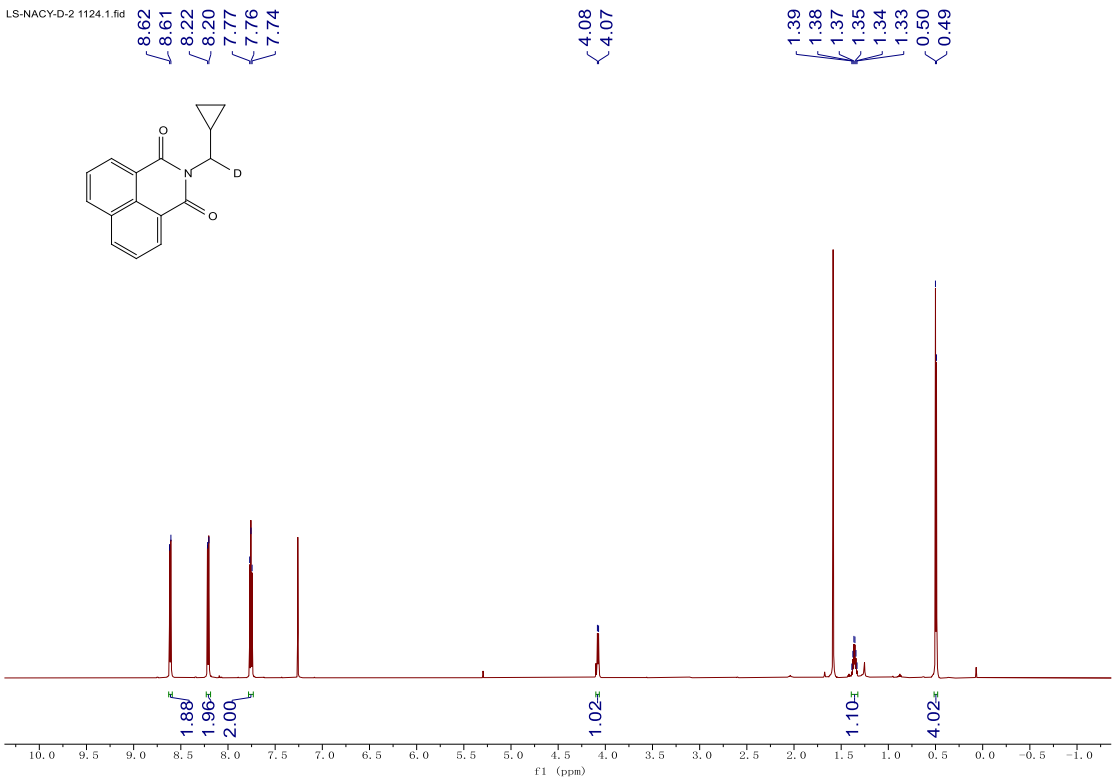
^{13}C NMR spectrum for compound **5b**



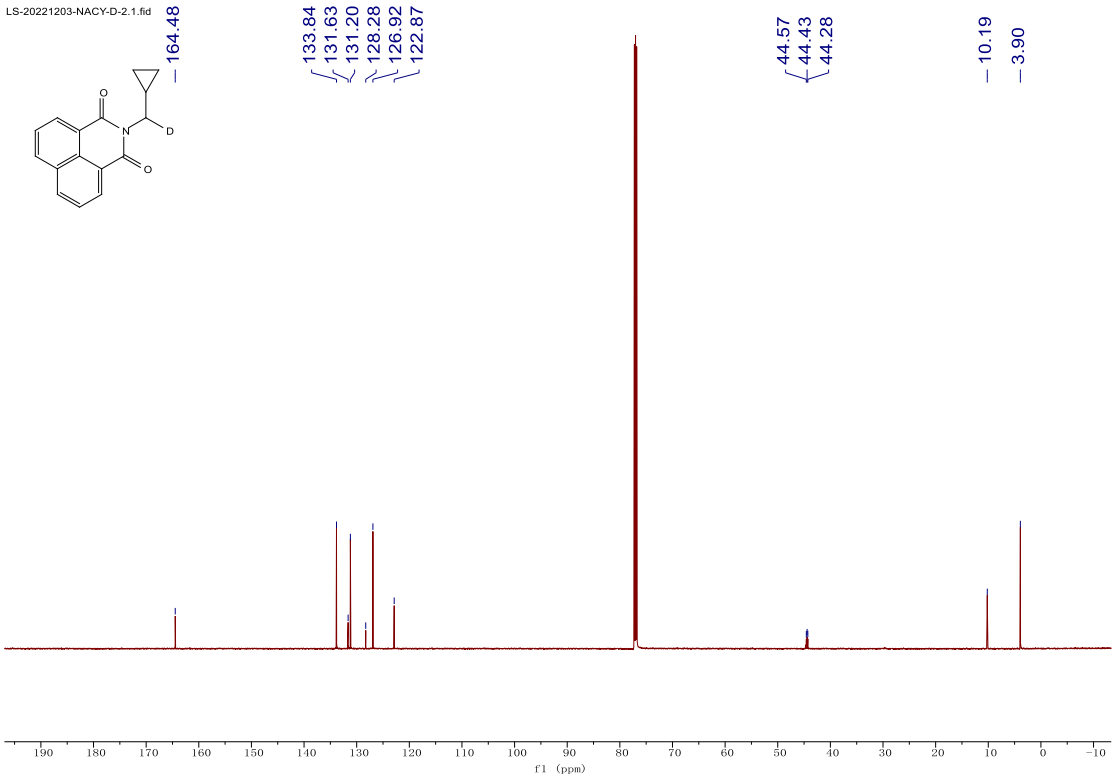
^{1}H NMR spectrum for compound **5m**



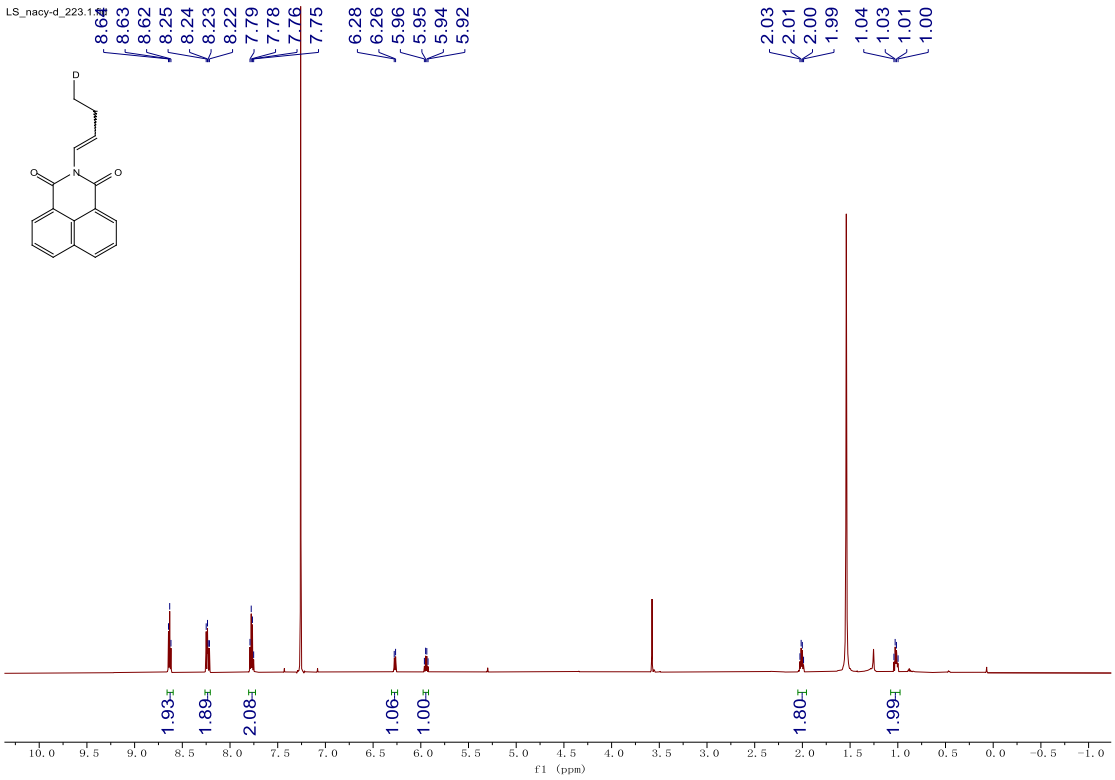
^{13}C NMR spectrum for compound **5m**



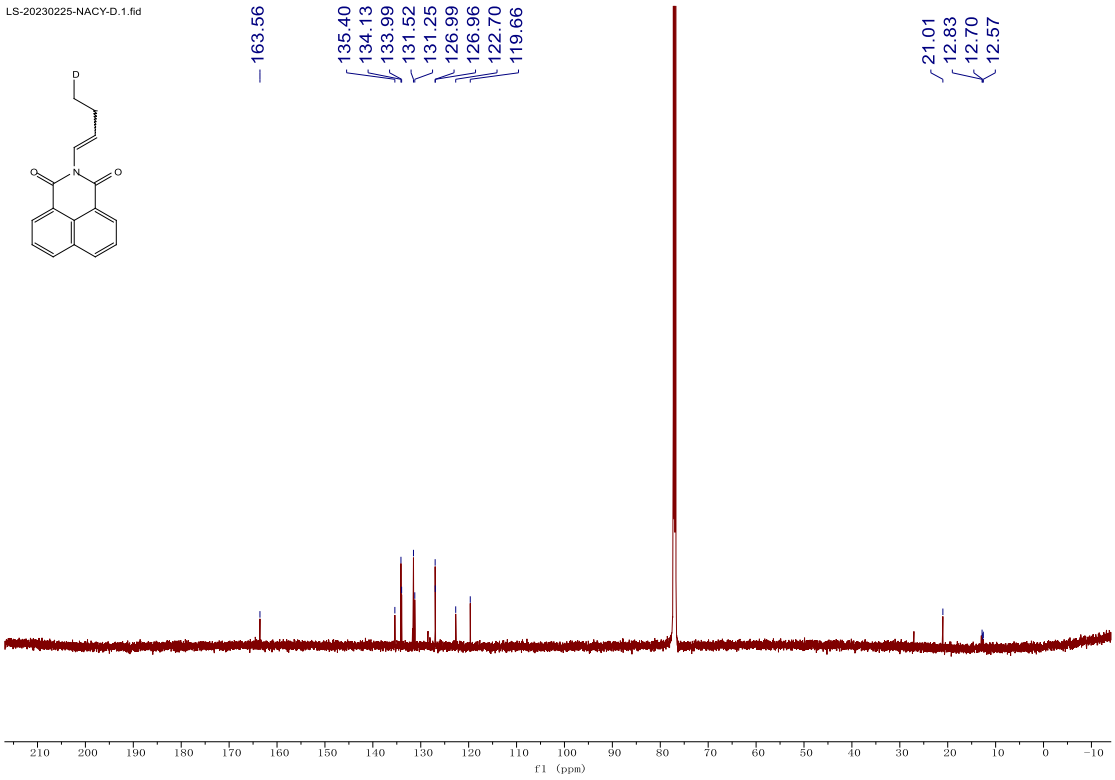
^{1}H NMR spectrum for compound **6c**



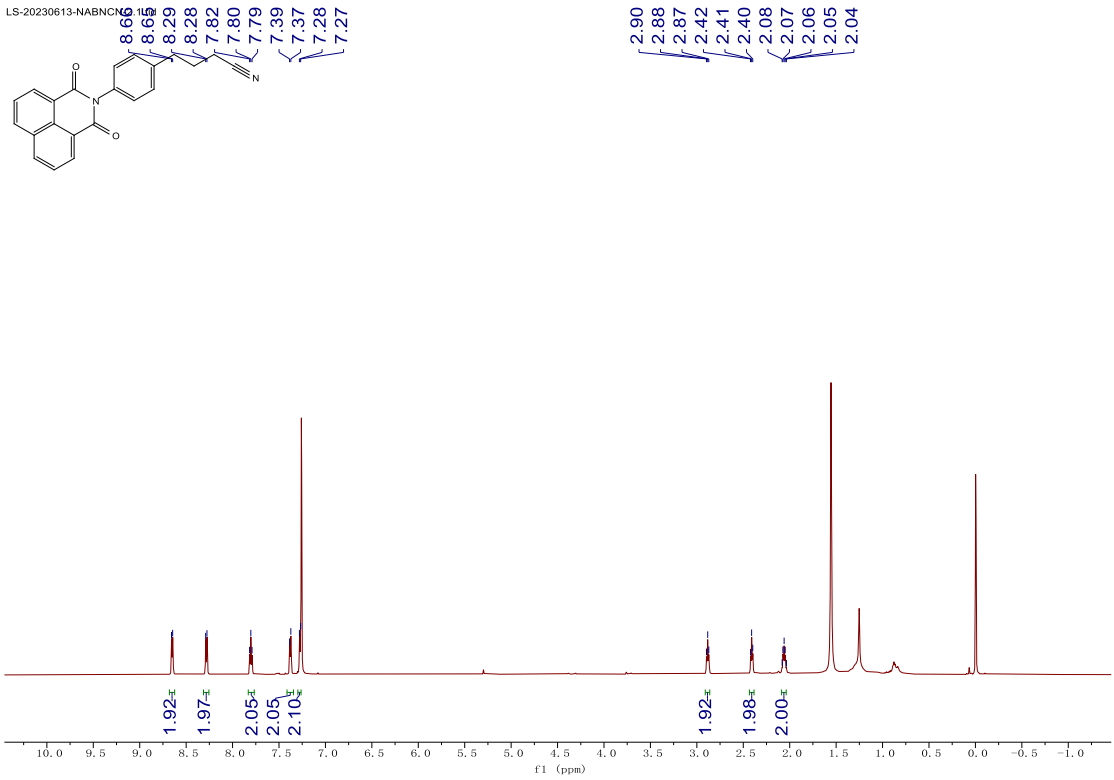
^{13}C NMR spectrum for compound **6c**



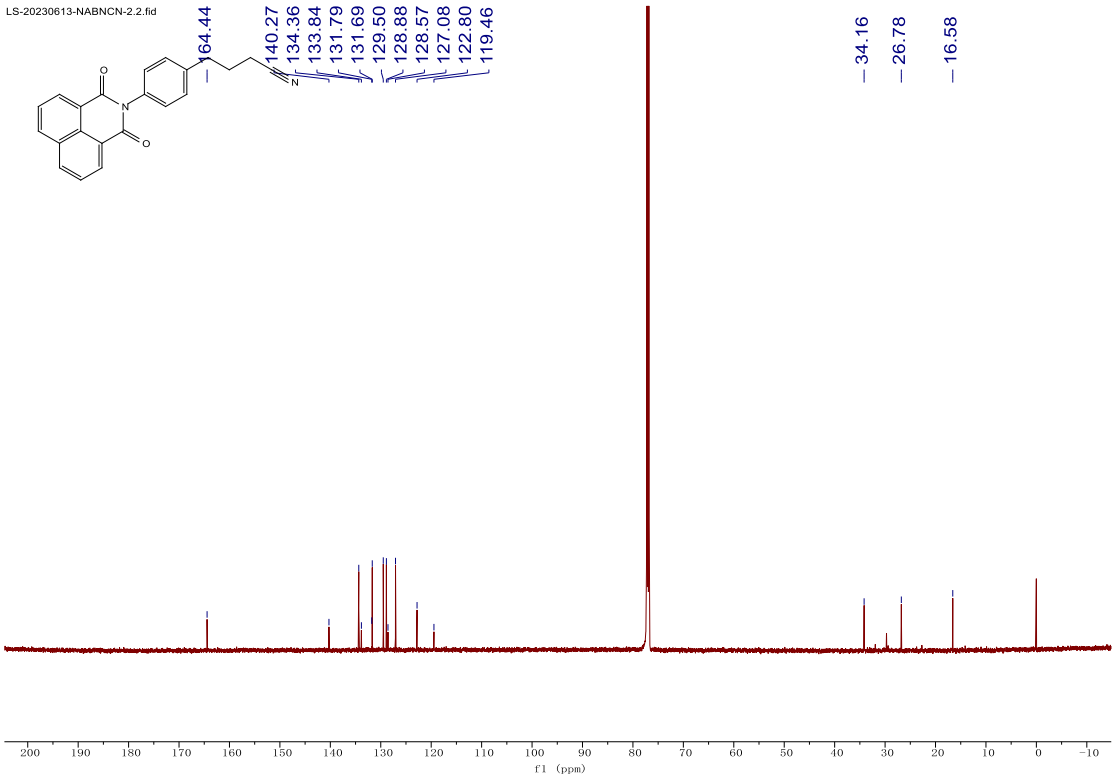
^{1}H NMR spectrum for compound **6d**



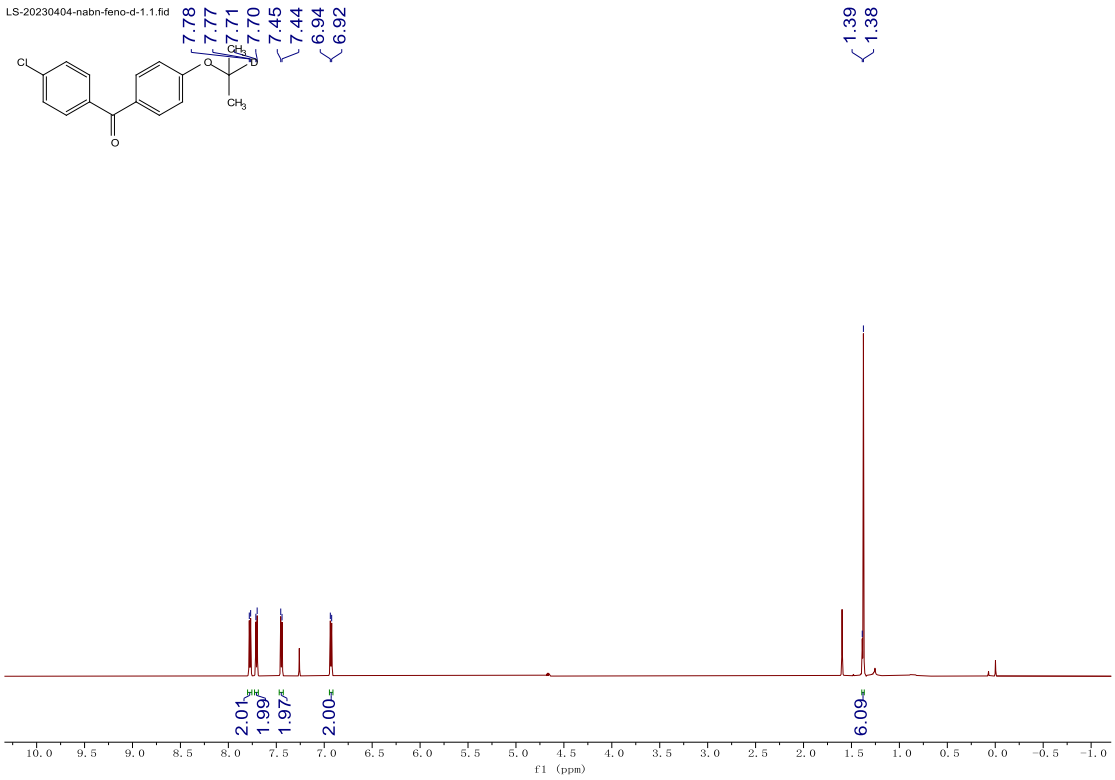
^{13}C NMR spectrum for compound **6d**



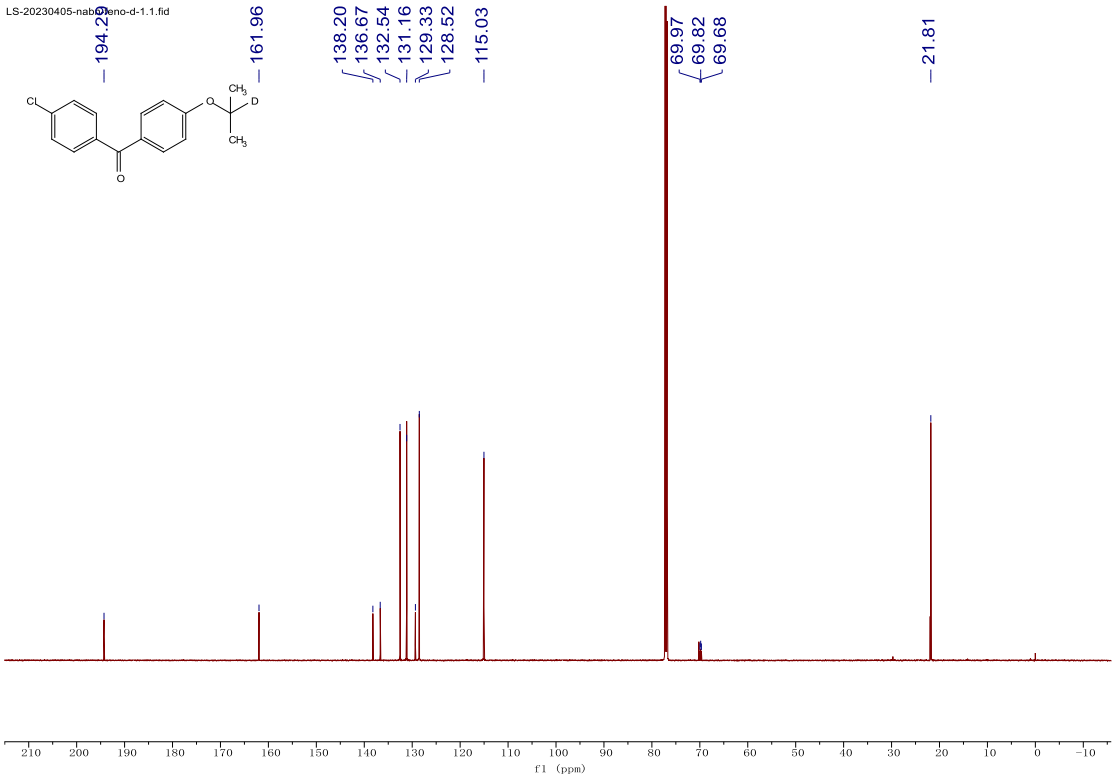
^{1}H NMR spectrum for compound **6e**



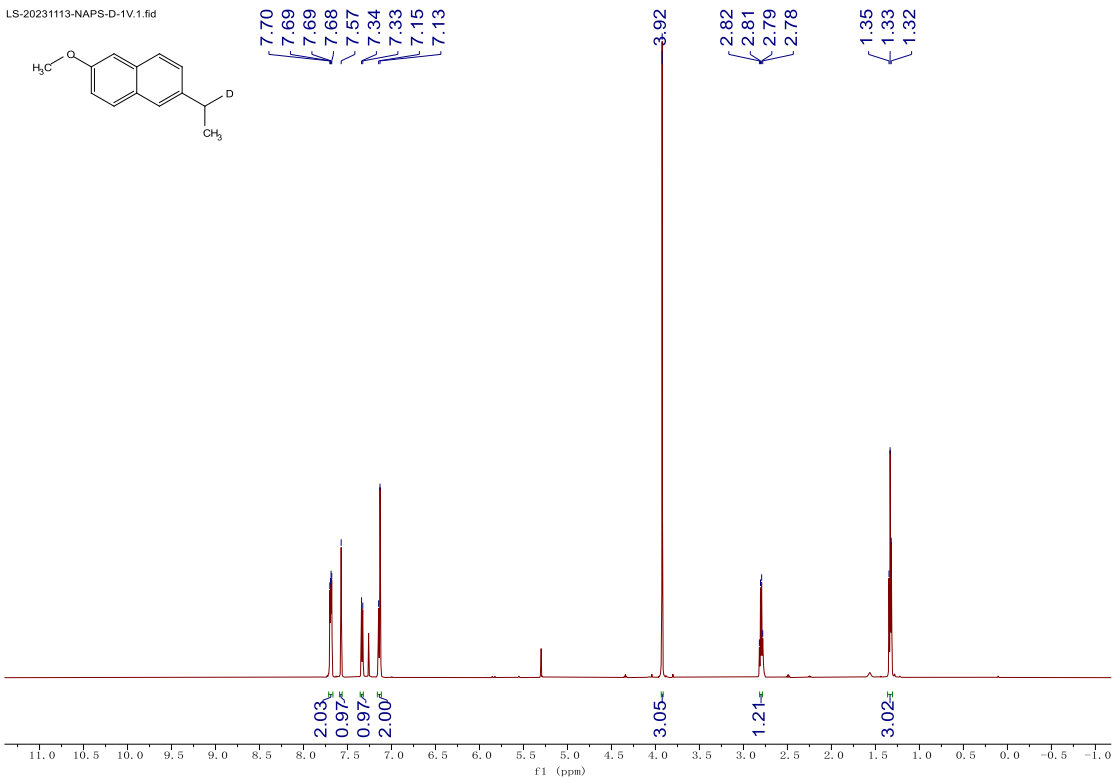
^{13}C NMR spectrum for compound **6e**



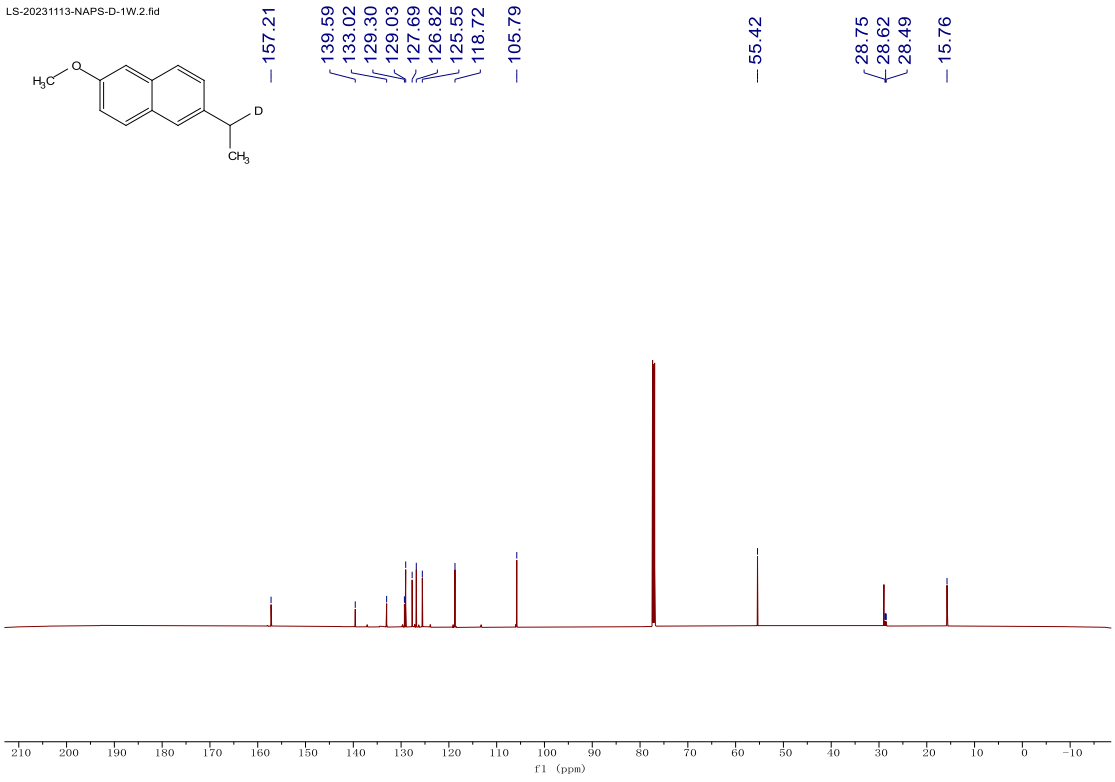
^{1}H NMR spectrum for compound **6f**



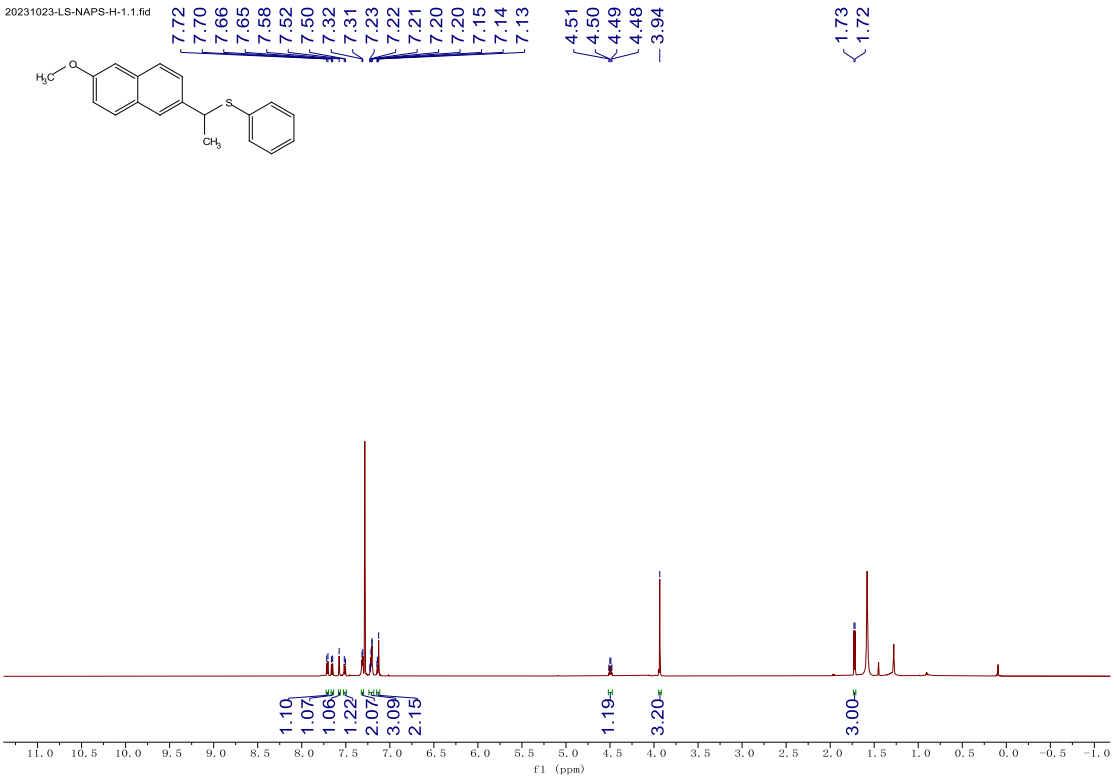
^{13}C NMR spectrum for compound **6f**



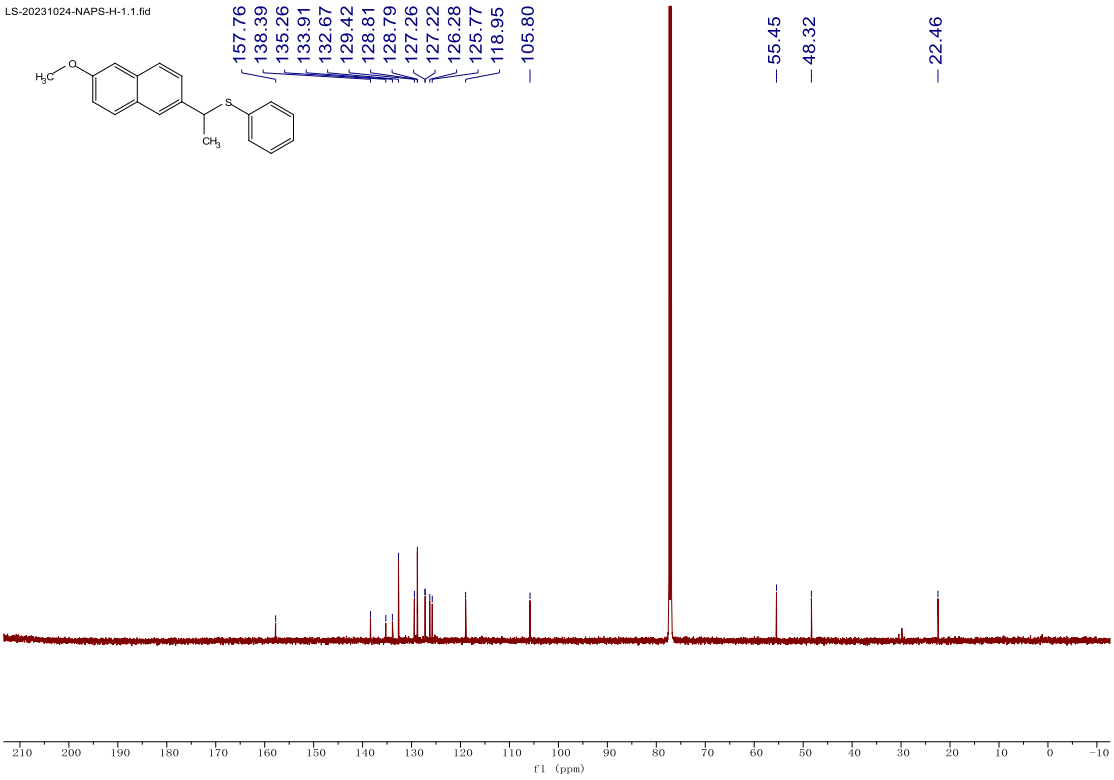
^{1}H NMR spectrum for compound **6g**



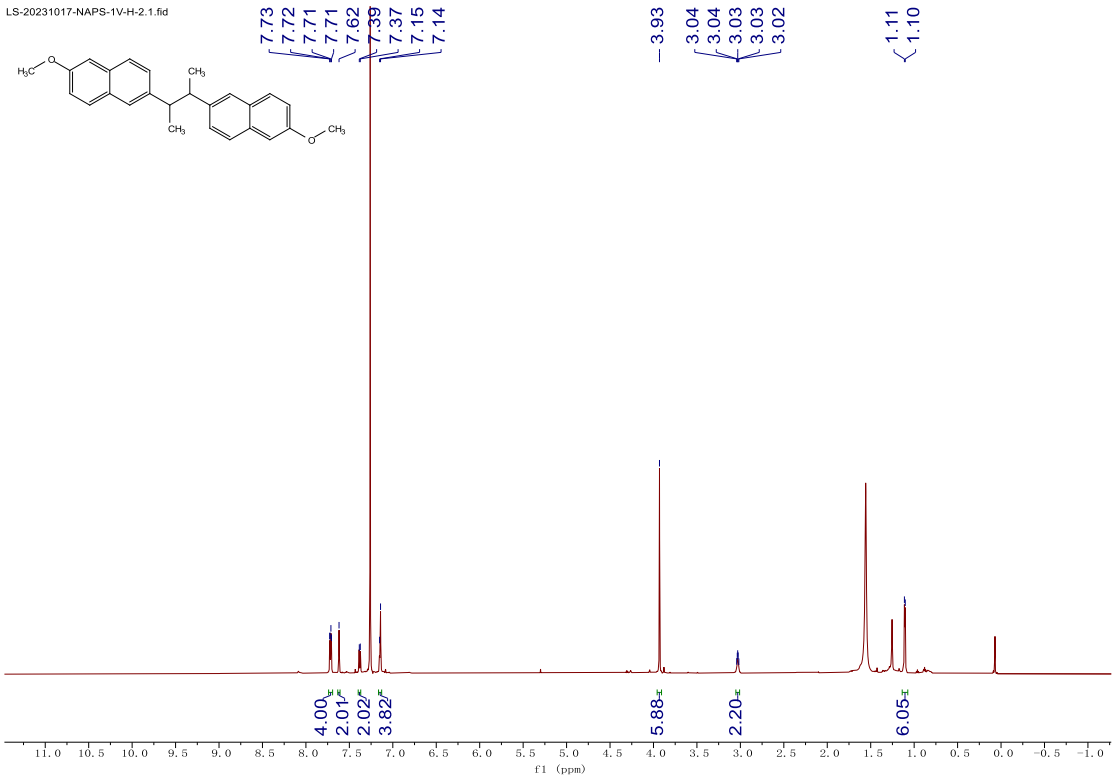
^{13}C NMR spectrum for compound **6g**



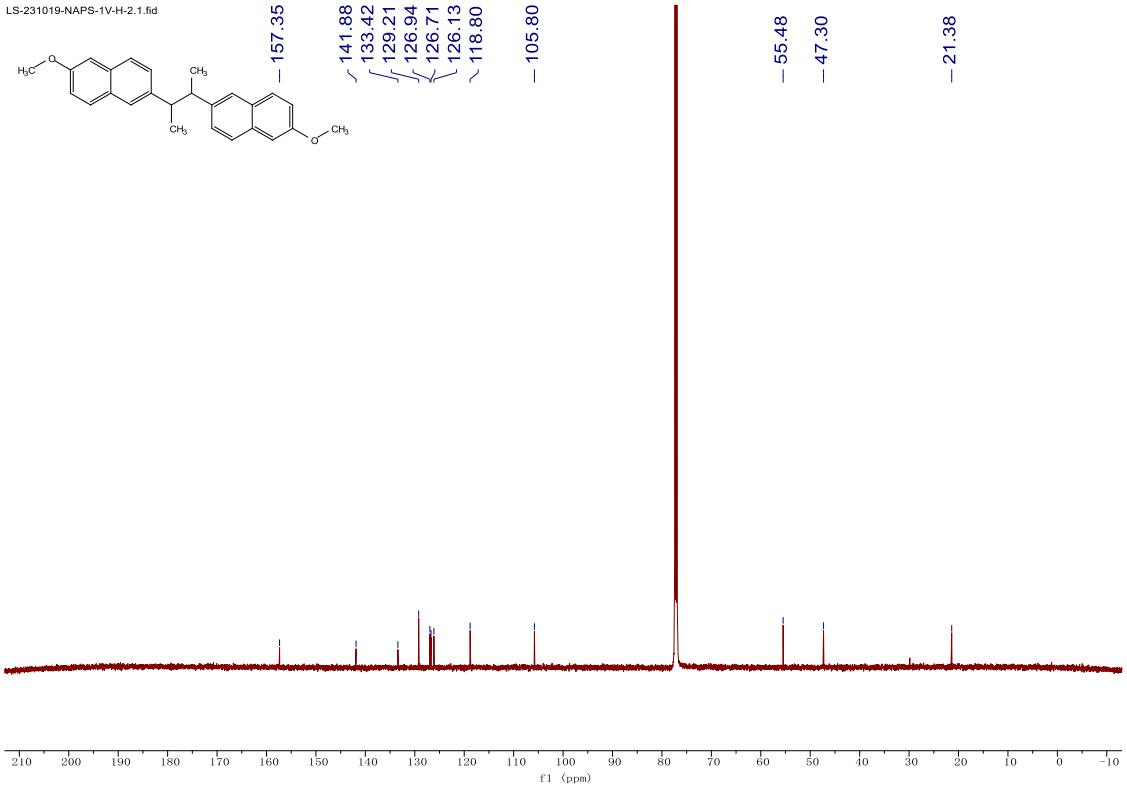
^{1}H NMR spectrum for compound **6h**



^{13}C NMR spectrum for compound **6h**



^{1}H NMR spectrum for compound **6i**



^{13}C NMR spectrum for compound **6i**